

This presentation was developed by UCBerkeley through a TT² grant from Caltrans, and delivered at 13 locations (October 2005 thru January 2006) to over 1400 Caltrans, Local Agency, Contractor and Tester participants. Our sincere thanks to Professor Carl Monismith, Dr. Rita Leahy, and Larry Santucci for the presentation materials and the excellent instruction. And, to our industry partners for assistance in advertising the sessions and their attendance at each session. Particularly the asphalt suppliers who participated in each round table session.

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Caltrans Implementation of PG Specs

PG - Performance Graded



Presentation Overview

- Why, When & How?
- How will it affect YOU?
 - Caltrans
 - Local Agencies
 - Industry
 - Consultants



HMA in California

- ~ 1 Ton HMA/Person/Yr
- ~ 34 Million Tons/Yr



Binder Specifications - Then & Now



Specification Systems

Penetration

Viscosity

PBA

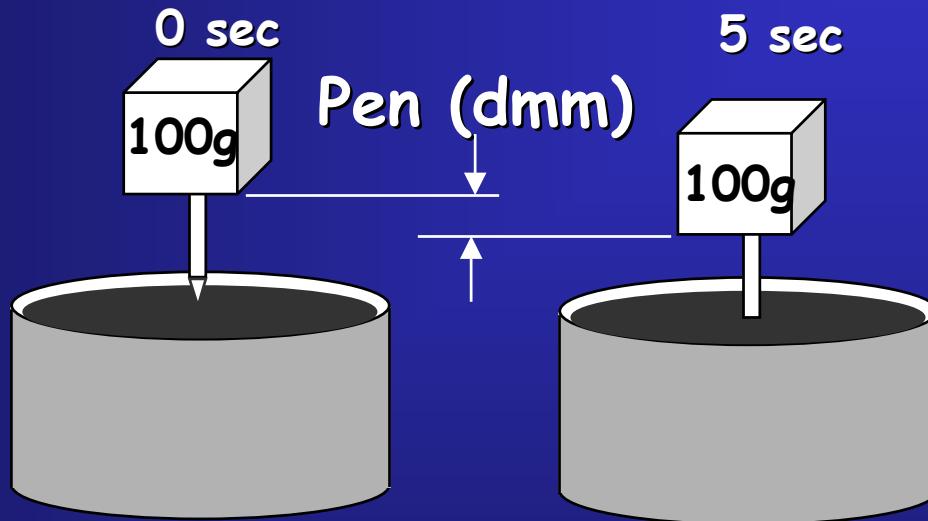
Superpave
PG

Penetration Grading System

- Introduced in 1918 by Bureau of Public Roads (now the FHWA)
- At least 9 penetration grades
- 1956 - PCCAS formed - Goal was to reduce the number of grades & standardize specs
- 1957 - PCCAS adopted 5 grades

PCCAS = West Coast User-Producer Group

Penetration Grading System



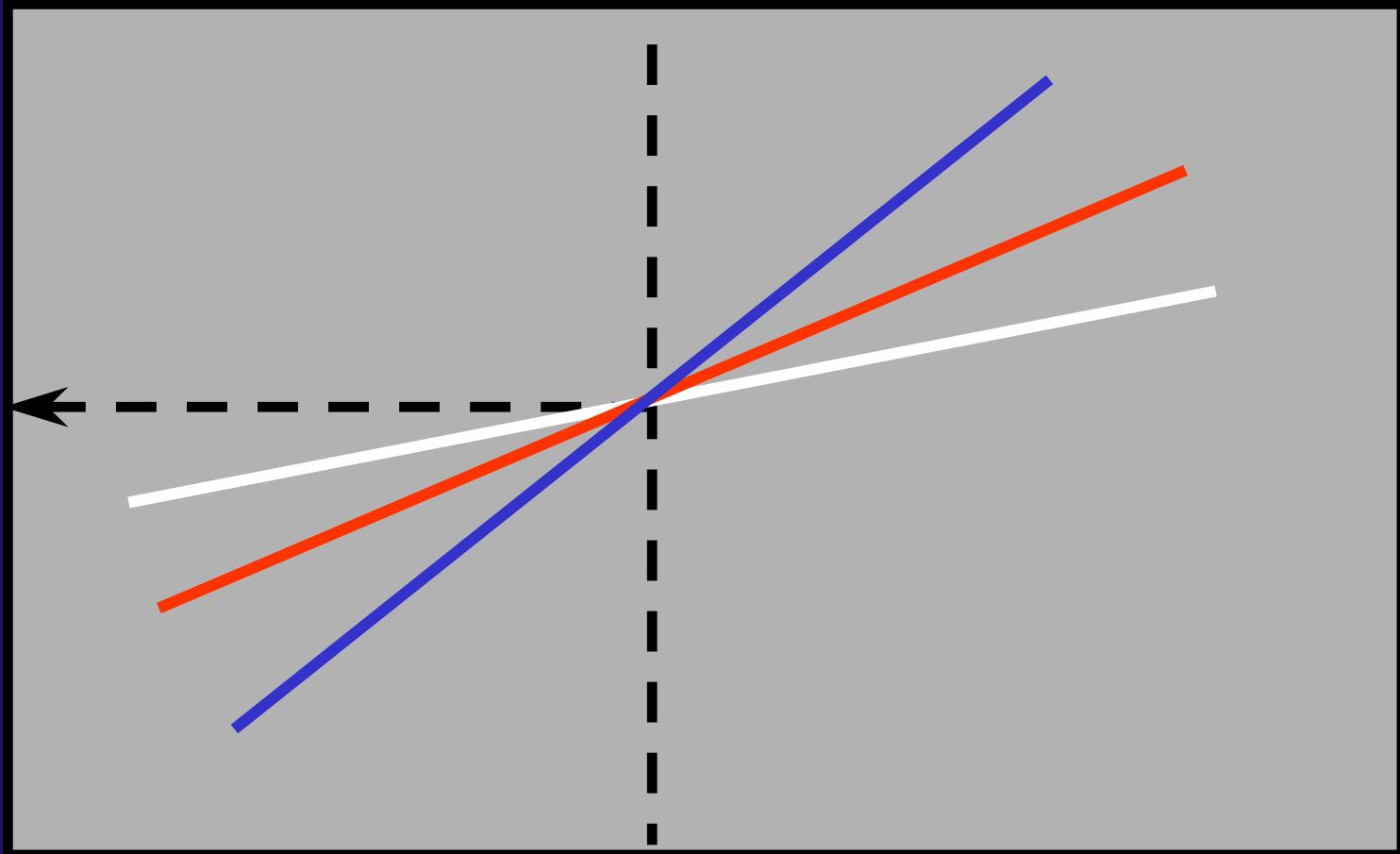
- Based on magnitude of the penetration of a standard needle at 25°C

Penetration Spec

- Classification based on pen at 25°C
- Also considers
 - Penetration at 4°C
 - Flash point
 - Viscosity at 135°C
 - Solubility
 - Thin Film Oven Aging
 - Penetration at 25°C
 - Ductility

Temp Susceptibility

Penetration, 0.1 mm



25°C (77°F) Temp

Viscosity Grading System

Original
Binder
(AC)

Aged
Residue
(AR)

Viscosity Grading System

AC

- Developed in 1960s
- Replace penetration system
- Based on unaged binder consistency at max in-service temp
- AASHTO M226 & ASTM D3381

AR

- Caltrans in the 1960s
- Based on aged binder to simulate post-mixing binder consistency

AC Spec Tests

- Classification based on vis at 60°C
- Also considers
 - Vis at 135°C
 - Pen at 25°C
 - Flash Point
 - Solubility
 - TFO-aged residue
 - Vis at 60°C
 - Ductility at 25°C

Viscosity Grades (AC-xx)

AC - 2.5

5

10

20

30

40

PCCAS and the AR

1967

1969

1972

1974

RTFOT adopted as alternative to TFOT

Use of RTFOT-conditioned asphalt began

Formally adopted

Implementation

Caltrans Grades & Tests

- Classification based on aged-residue vis at 60°C
- AR Grades*
 - AR -1000
 - 2000
 - 4000
 - 8000
 - 16000

* *Caltrans Std Specs, Section 92*

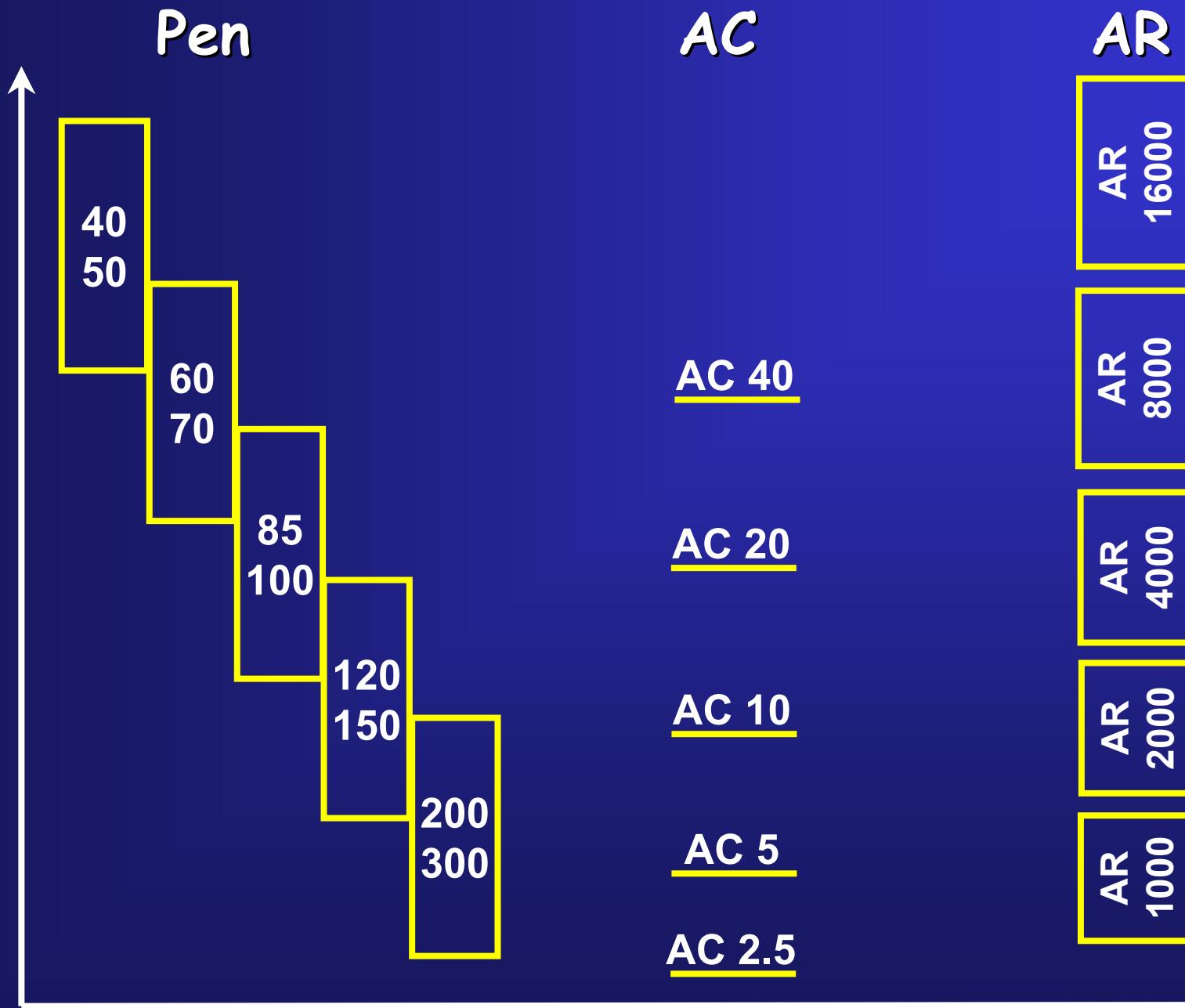
"Greenbook" Section 203-1

Caltrans Grades & Tests

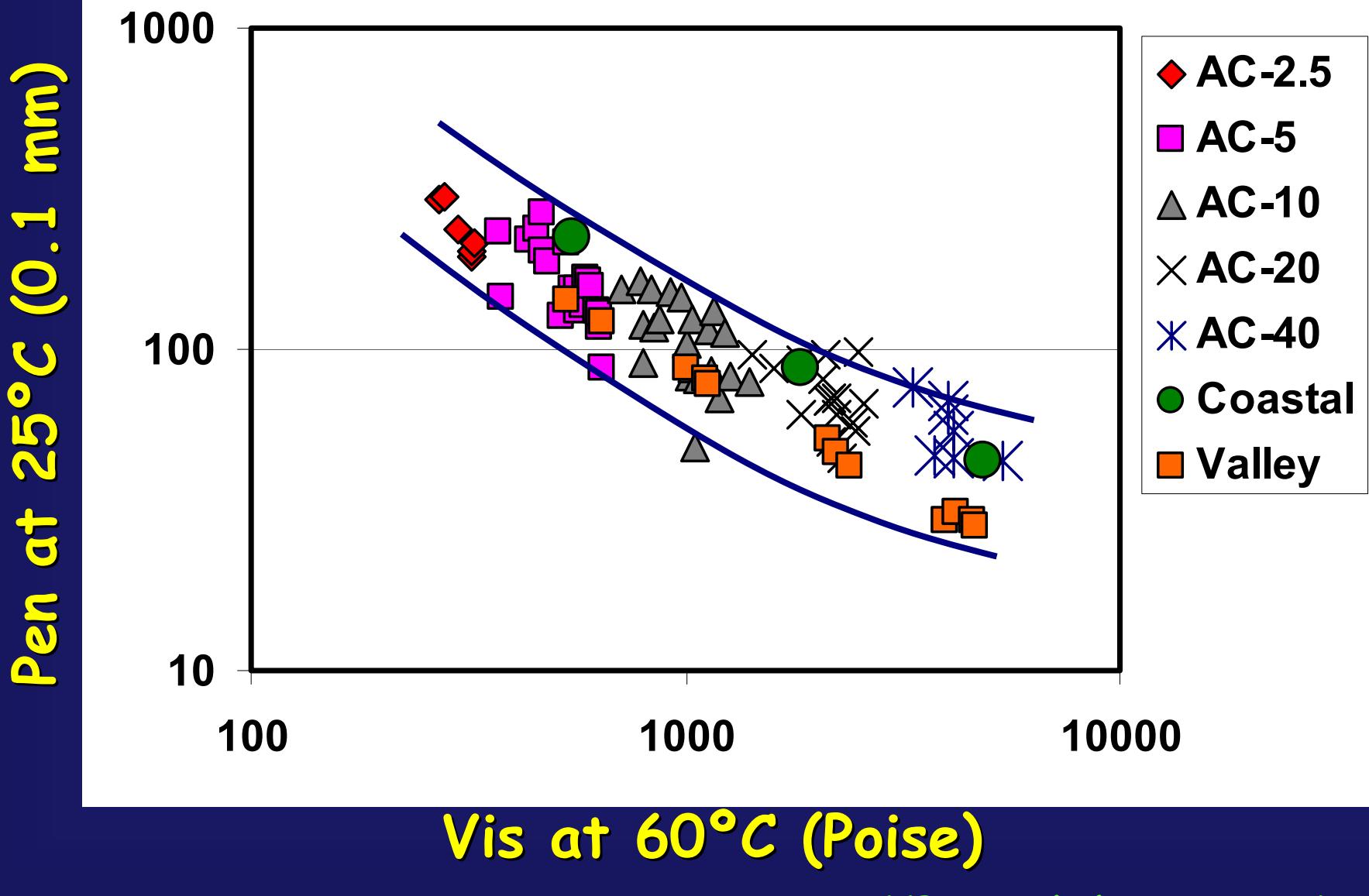
- Also considers tests on RTFO-aged residue
 - Vis at 60°C & 135°C
 - Pen at 25°C
 - % of Original Pen
 - Ductility
 - Properties of unaged asphalt
 - Flash Point
 - Solubility

Comparison of Pen & Vis Grades

Log of Relative Stiffness



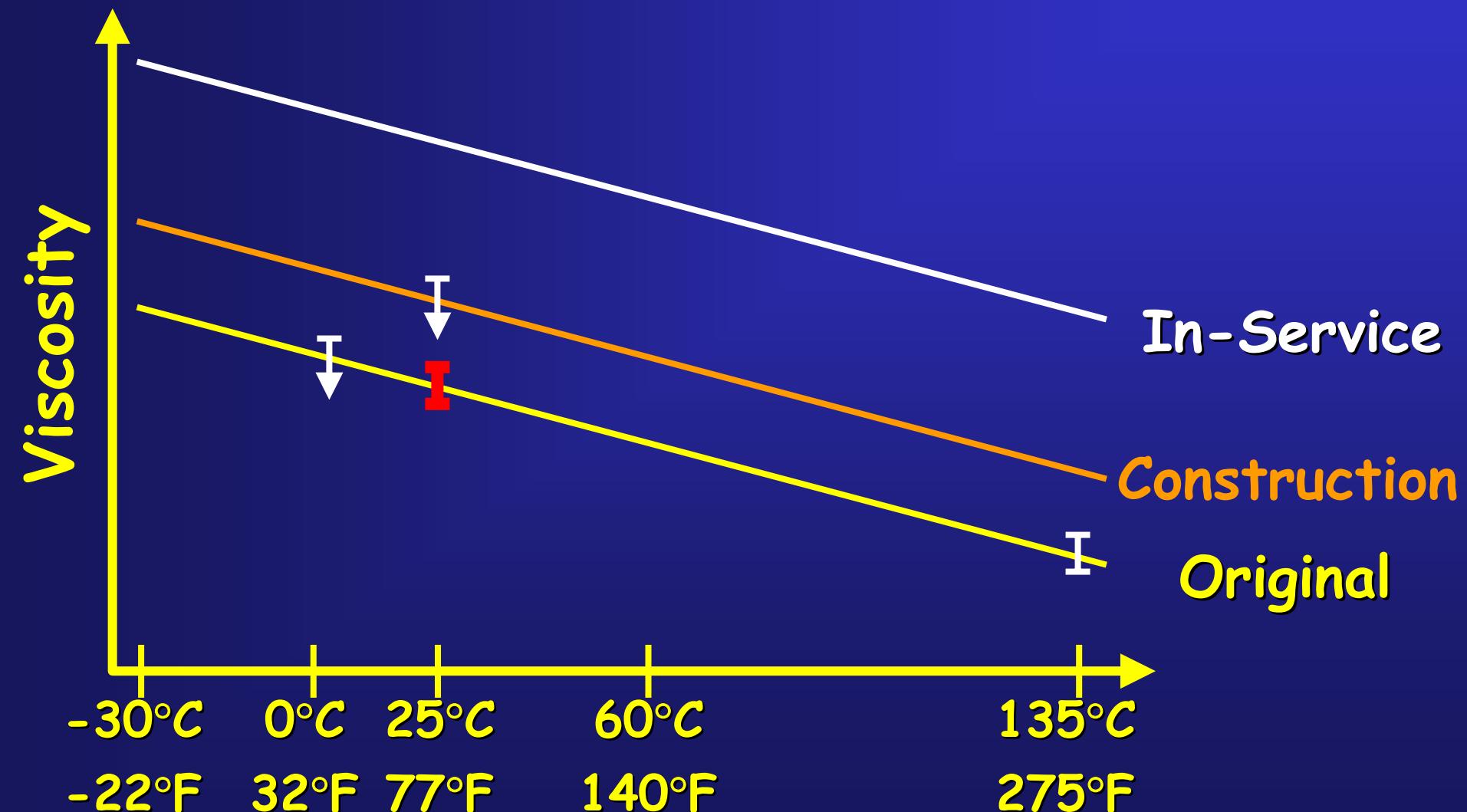
Relationship Between Vis & Pen



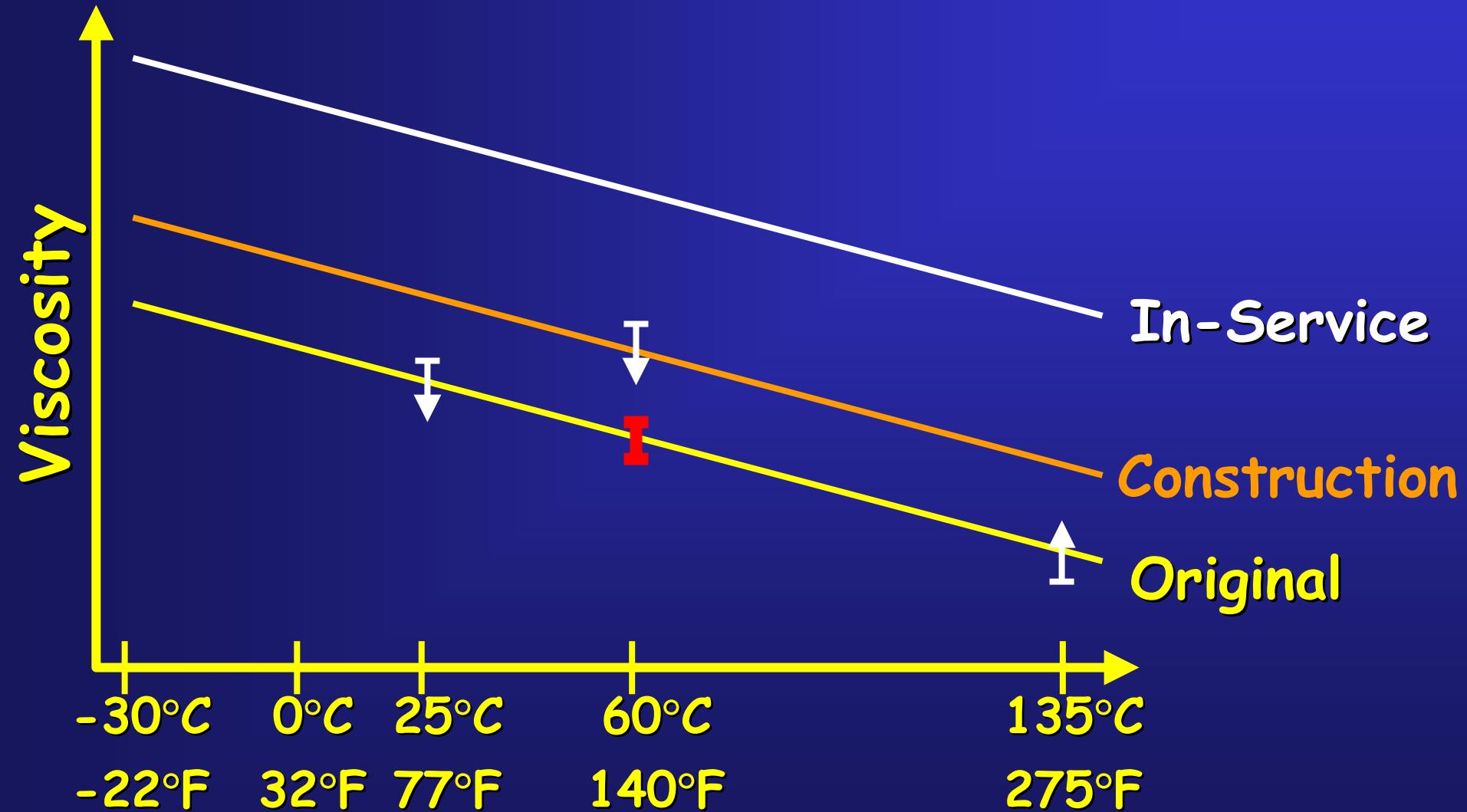
Limitations of Pen & Vis Grading Systems

- Penetration: Empirical measurement
- Viscosity: Viscous effect only
- No low temp properties (except PCCAS-pen ratio)
- Long-term aging not considered
- Inadequate for modified binders

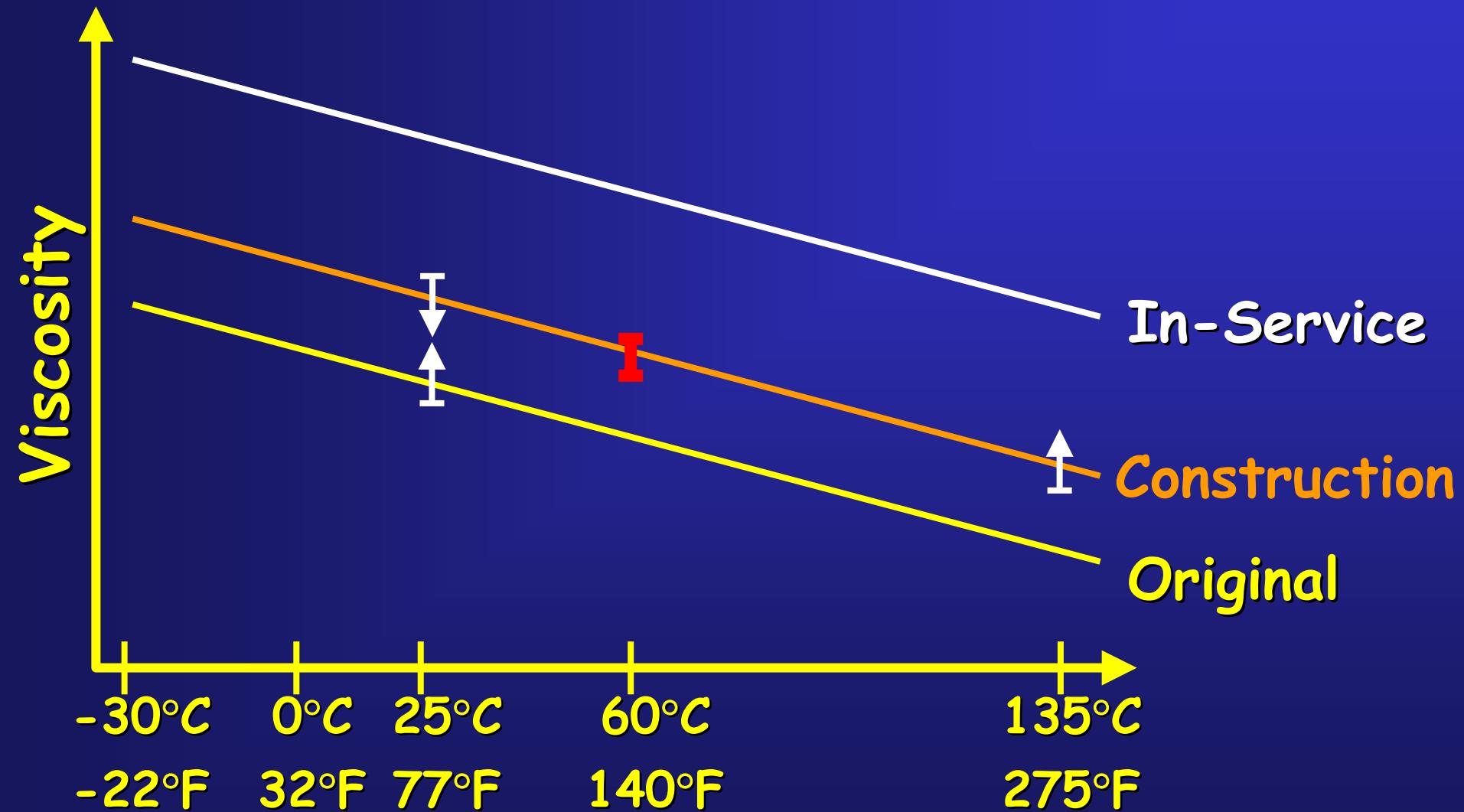
Penetration Spec



AC Viscosity Spec



AR Viscosity Spec



PCCAS to the Rescue

- 1987 - Paving Asphalt Committee charged to develop specs for modified asphalts
- Representatives from
 - Industry - Chevron & Golden Bear
 - ODOT
 - Caltrans

PBA Concept

Performance

Rutting, Fatigue & Low Temp Cracking

Safety

Environment

Purity

Compatibility

Climate

PBA Grade



Binder Tests

	1	2	3	4	5	6	7
Test Criteria							

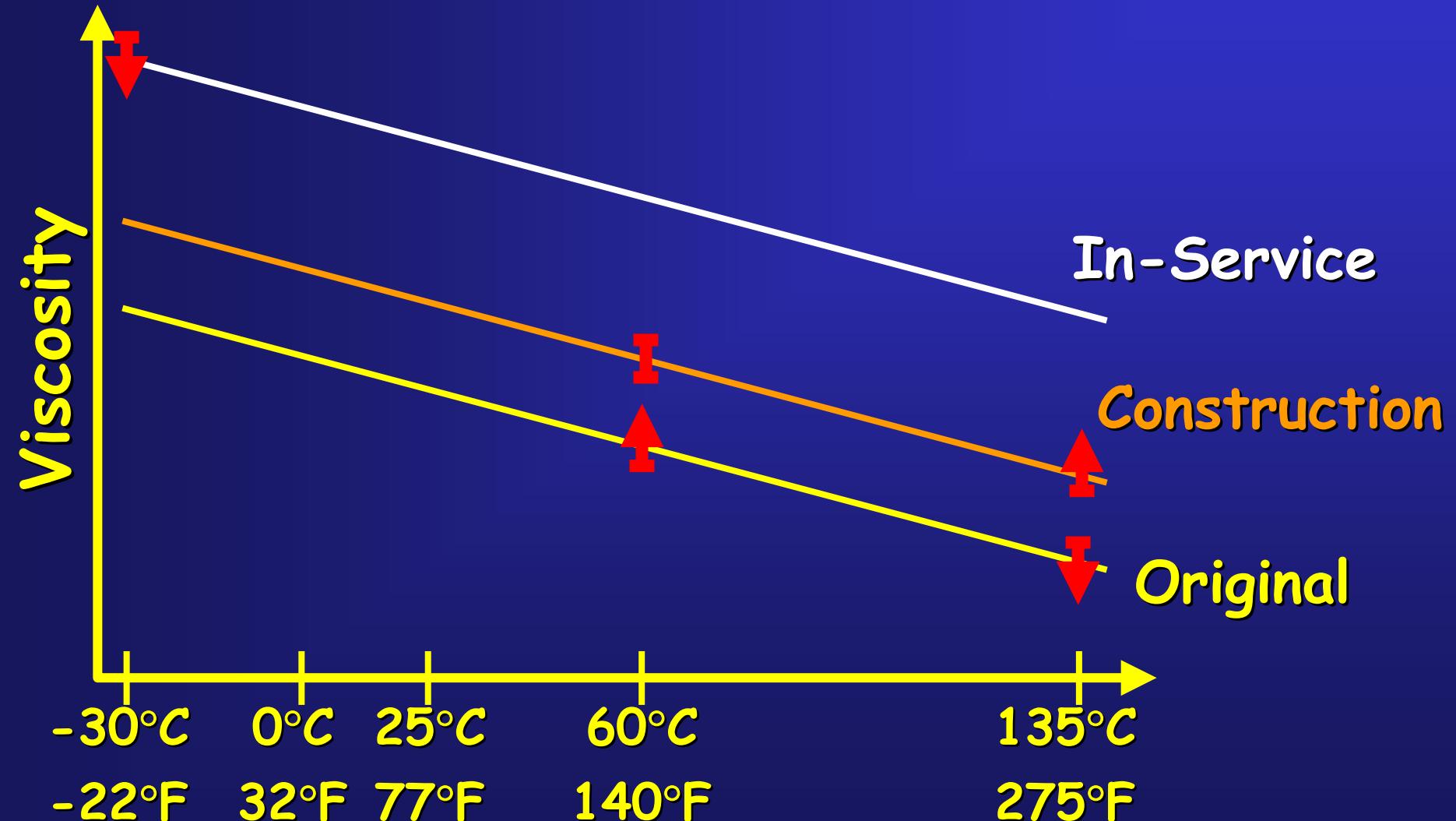


PBA Spec - 1992

- Precursor to SHRP PG
- Climatic guidelines to select grade
- Conventional tests to relate to performance
- Unique grades
 - PBA (performance-based asphalt)
- Identifies modified binders by grade

*Current PBA Spec -
Handout*

PBA Spec (eg. PBA 6a)



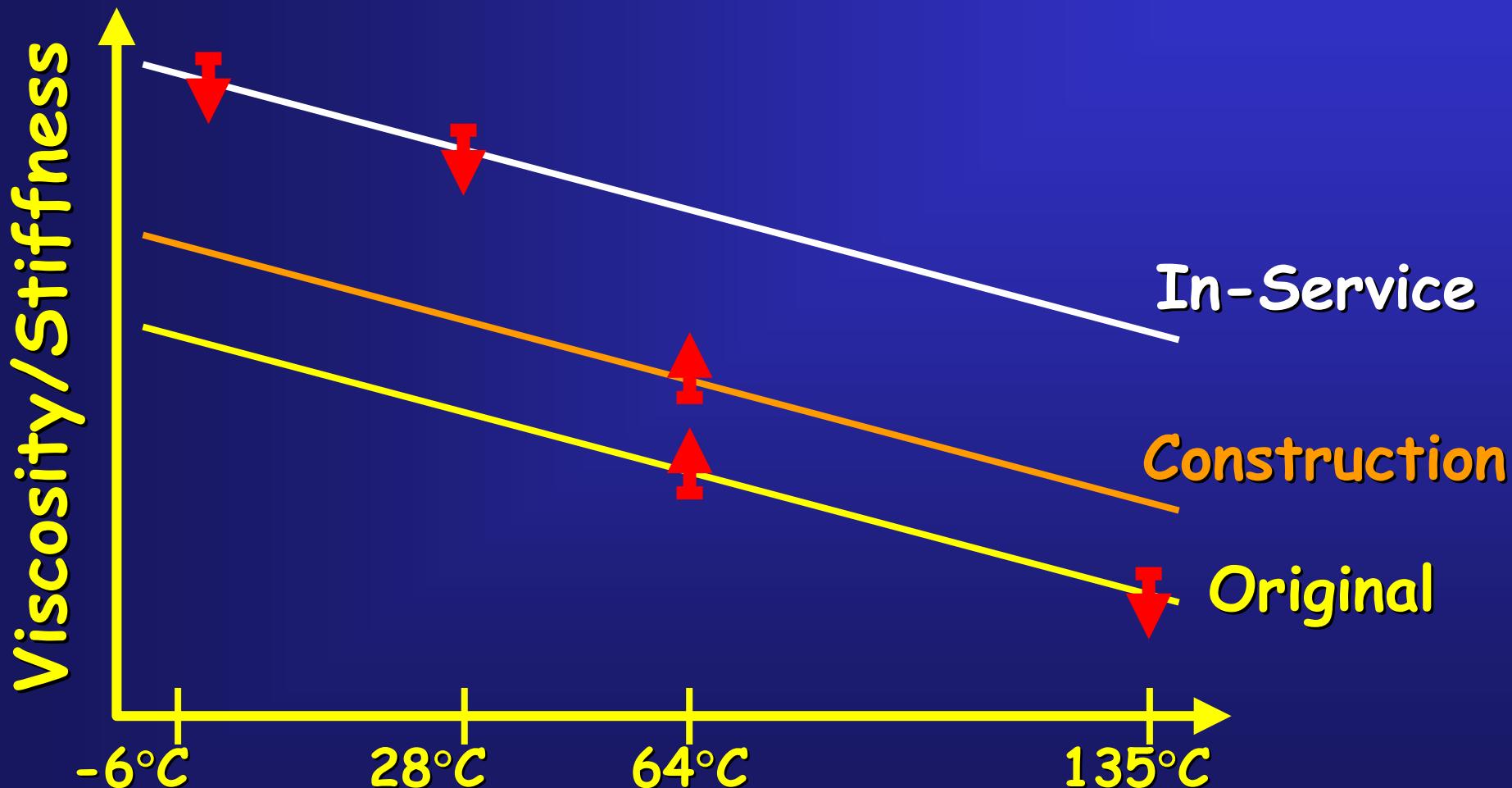
"PG" Asphalt Binder System

PG - Performance Graded

PG System

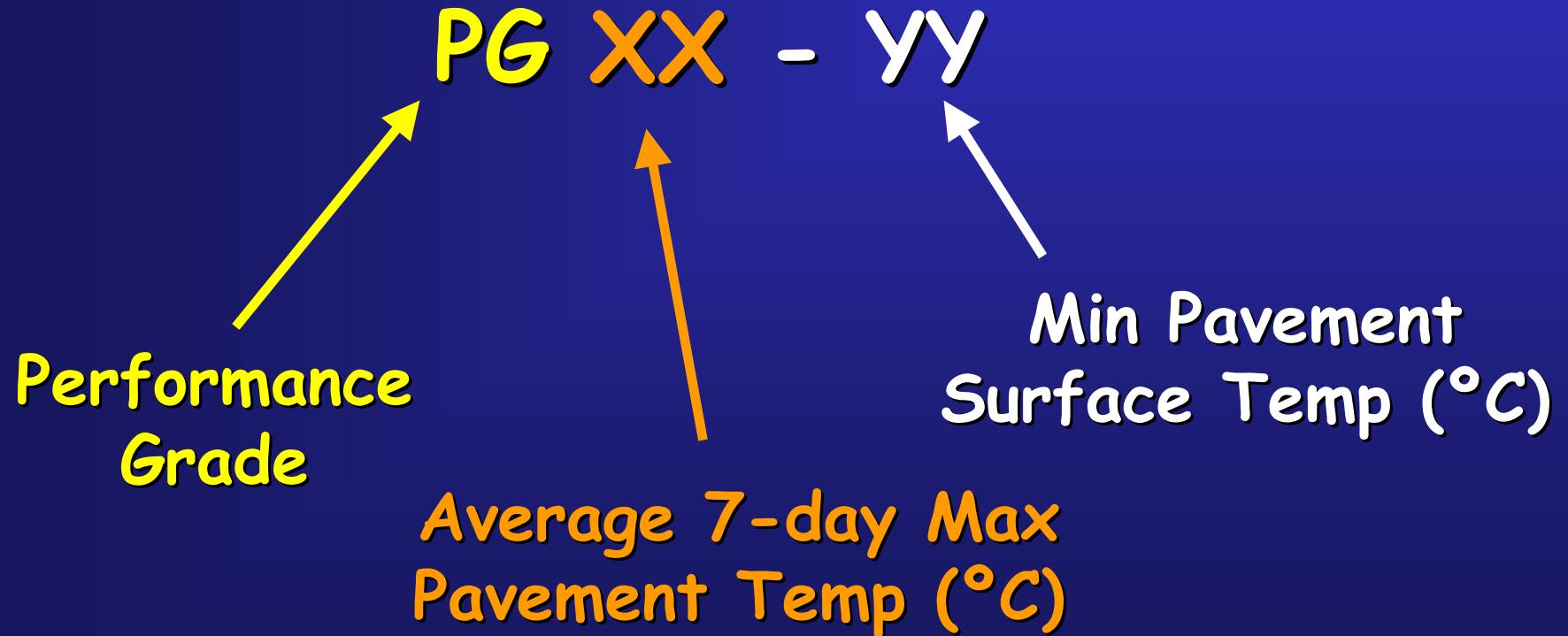
- Developed in 1990s during SHRP in concert w/ PCCAS
- Fundamental Properties, ie, stress and strain
- Unmodified binders
- Performance Considerations
 - Rutting, Cracking (Fatigue & Low Temp), & Aging
- Environment

PG Spec (eg, PG 64-16)



PG Spec

System Based on Climate -
In-Service Pavement Temps



Determination of Pavement Temp Used in PG Spec

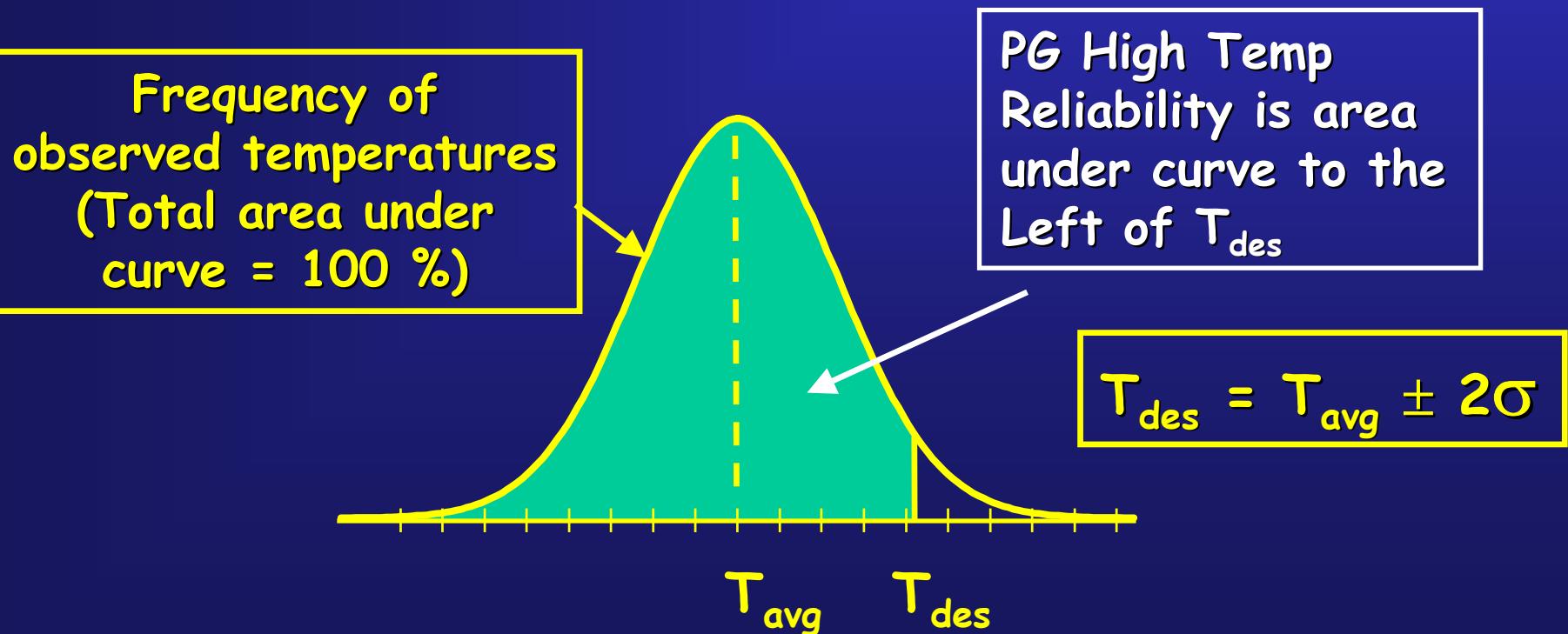
- Determine-Project Specific Air Temps
- Compute Design-Specific Pavement Temps from Air Temps

Air Temps

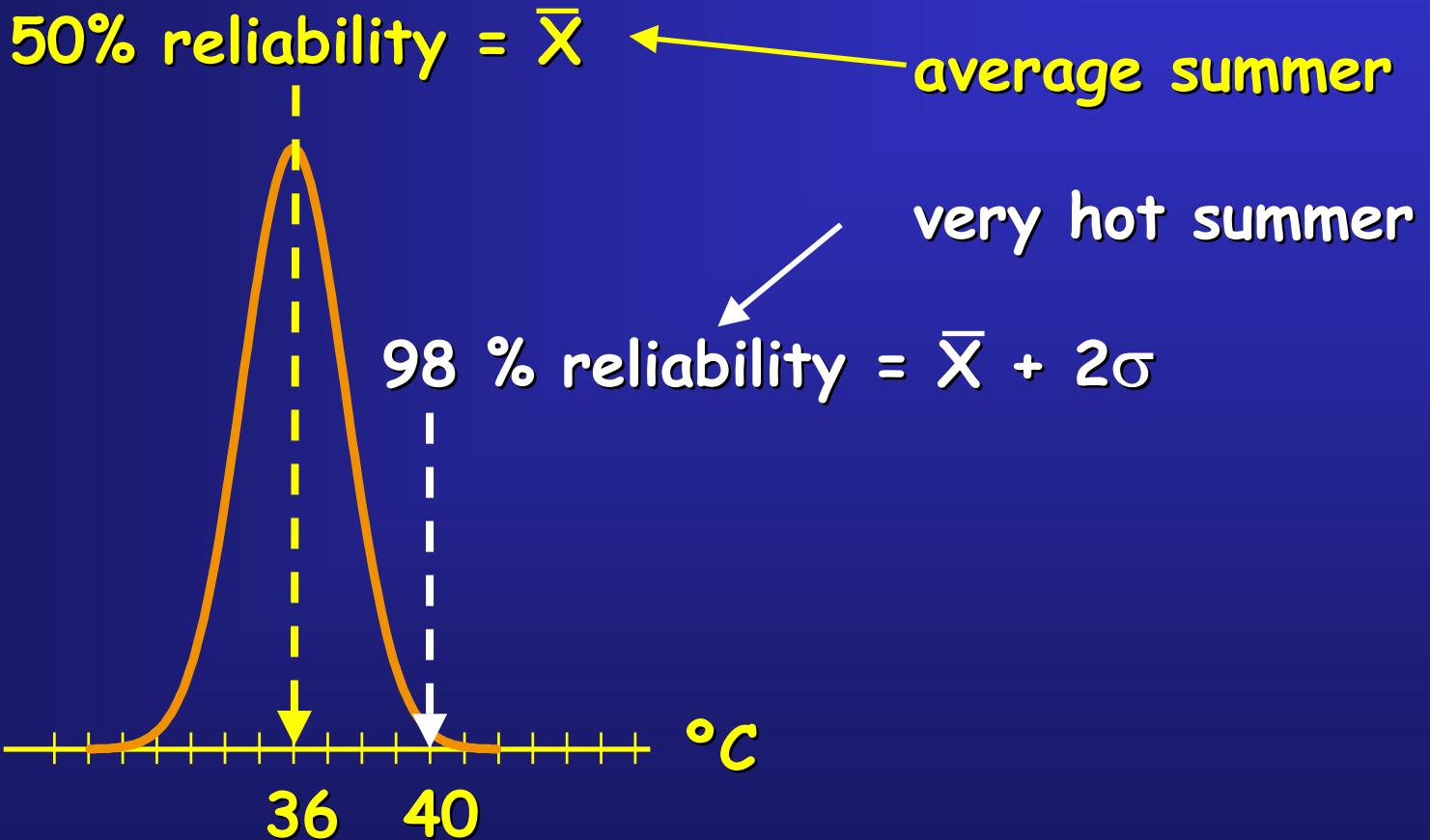
- Superpave Weather Database
 - NOAA ~ 40 years of data
 - 7,900+ stations in US & Canada
 - 308 stations in California
- Uses Annual Air Temps
 - Hottest, consecutive 7-day temp (average & standard deviation)
 - Coldest temp (average & standard deviation)
- Calculated Pavement Temps used in PG Selection

Reliability

- Percent Probability of Not Exceeding Design Temp
- Generated from Site Specific Mean and Standard Deviation

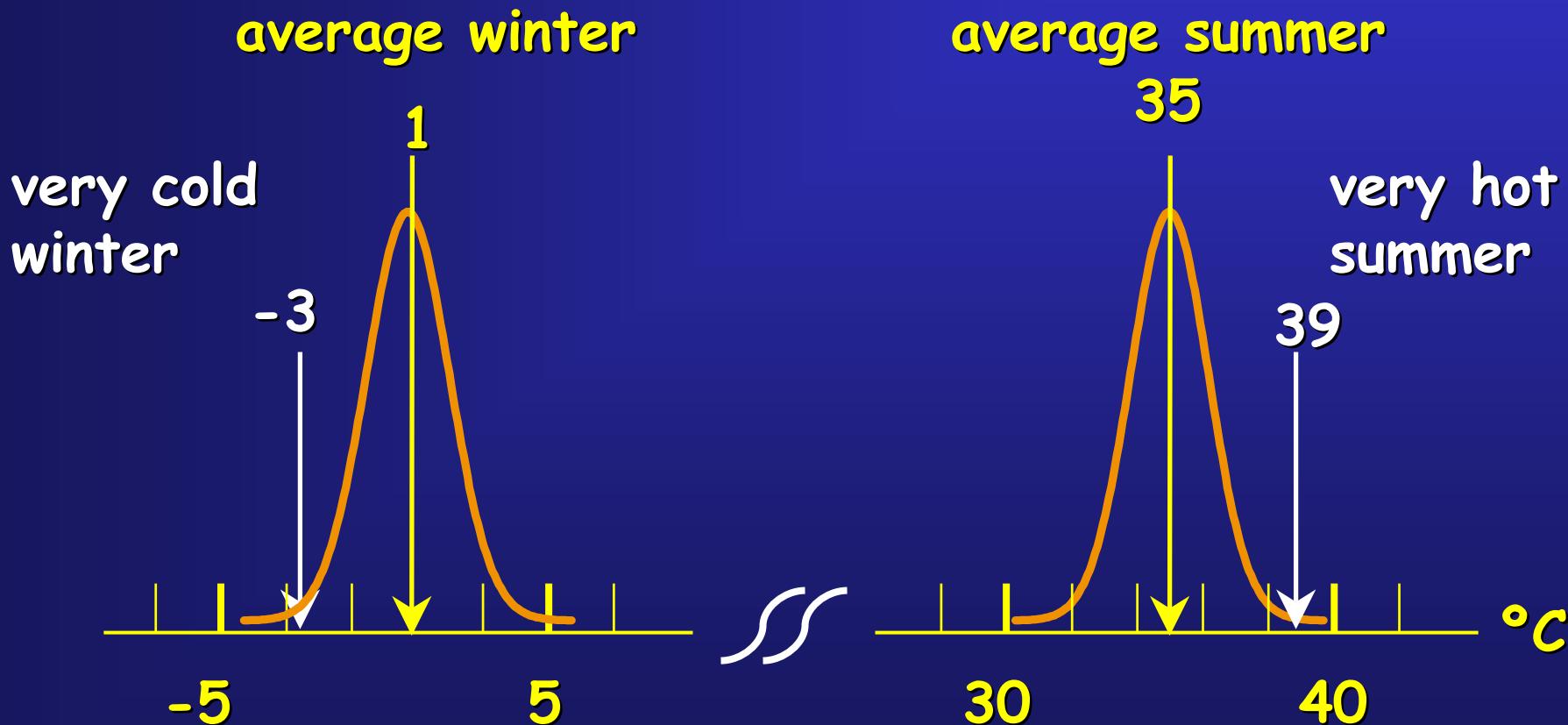


Observed Air Temps

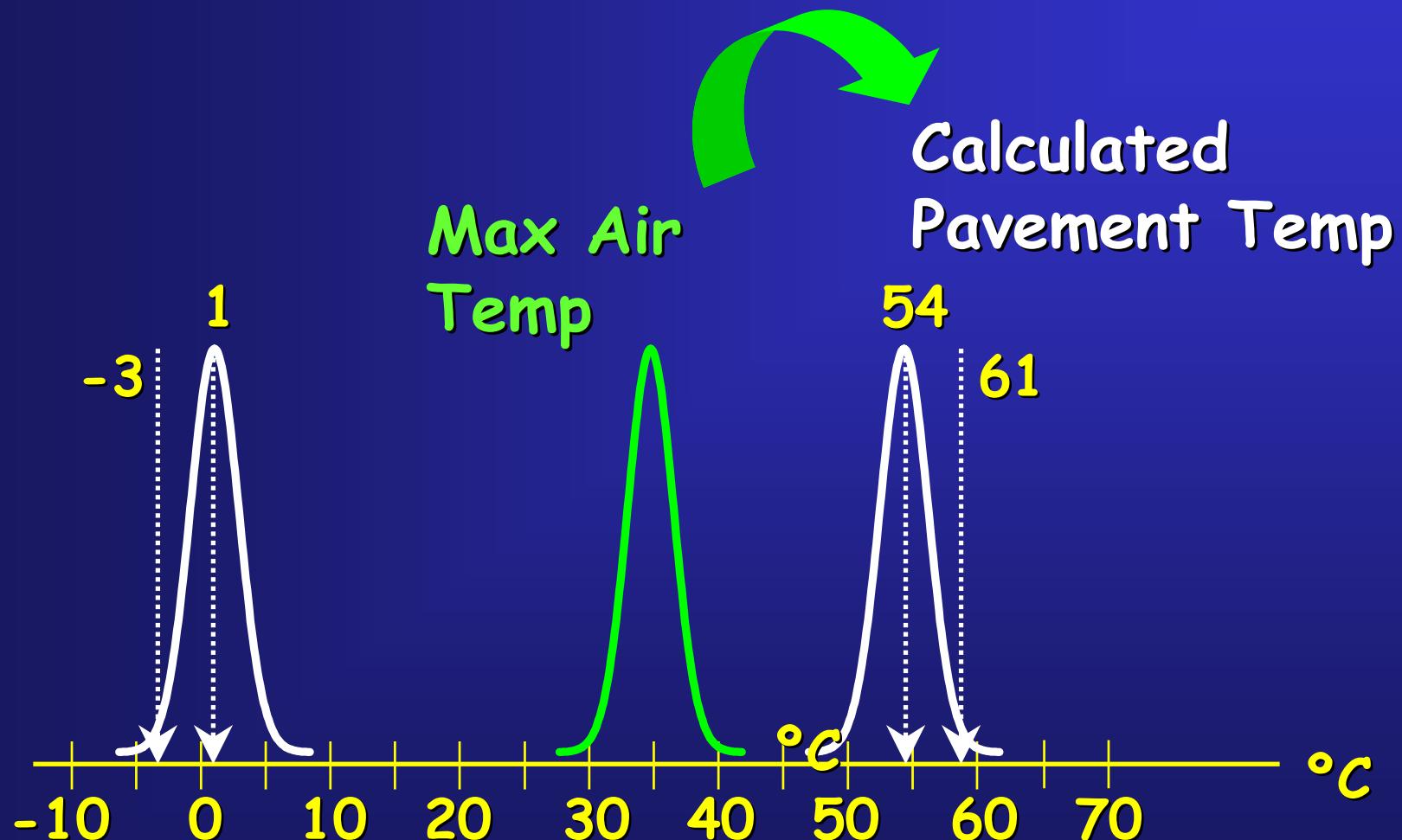


7-Day Max Air Temps

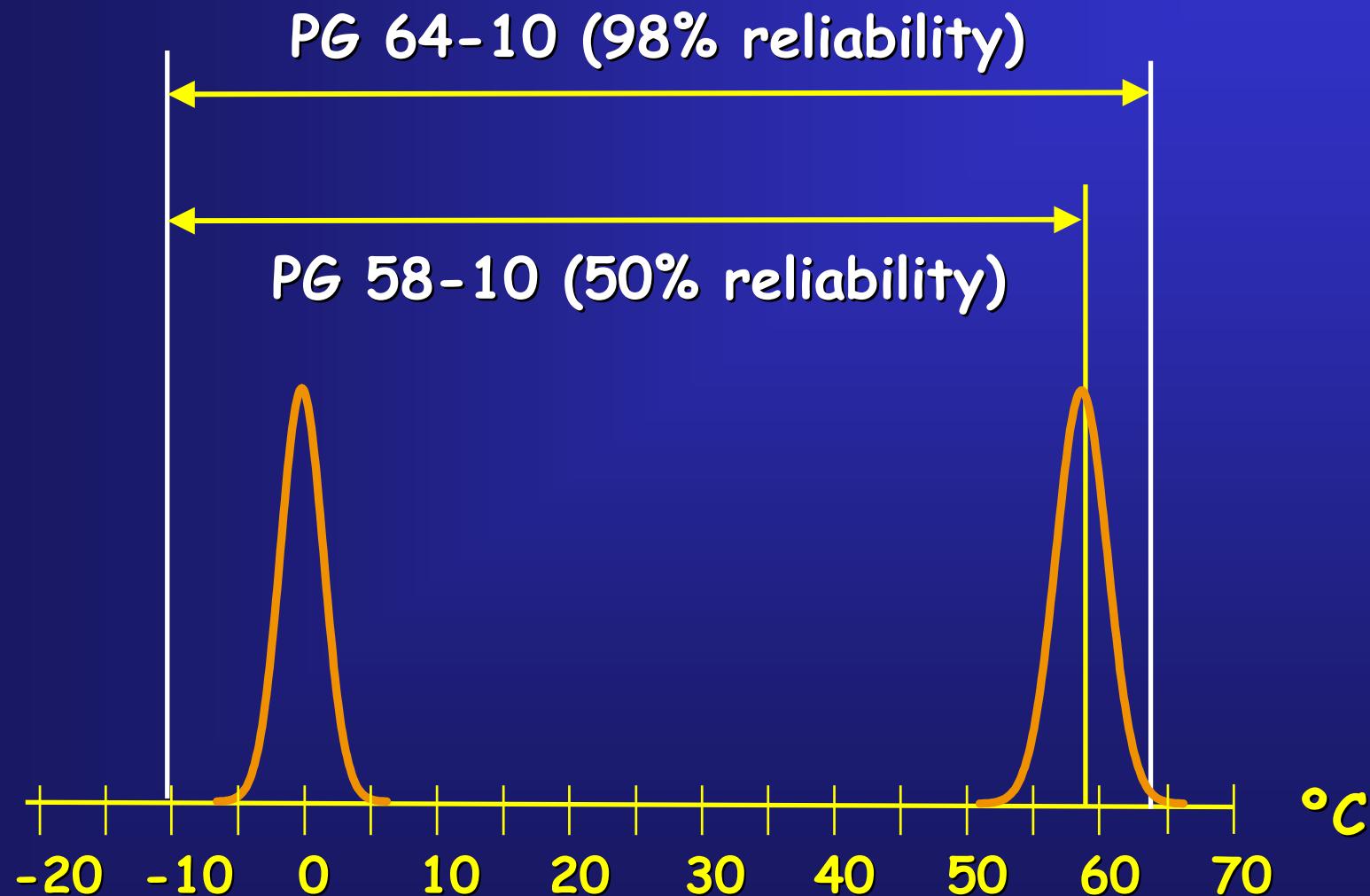
Observed Air Temps - San Diego (La Mesa)



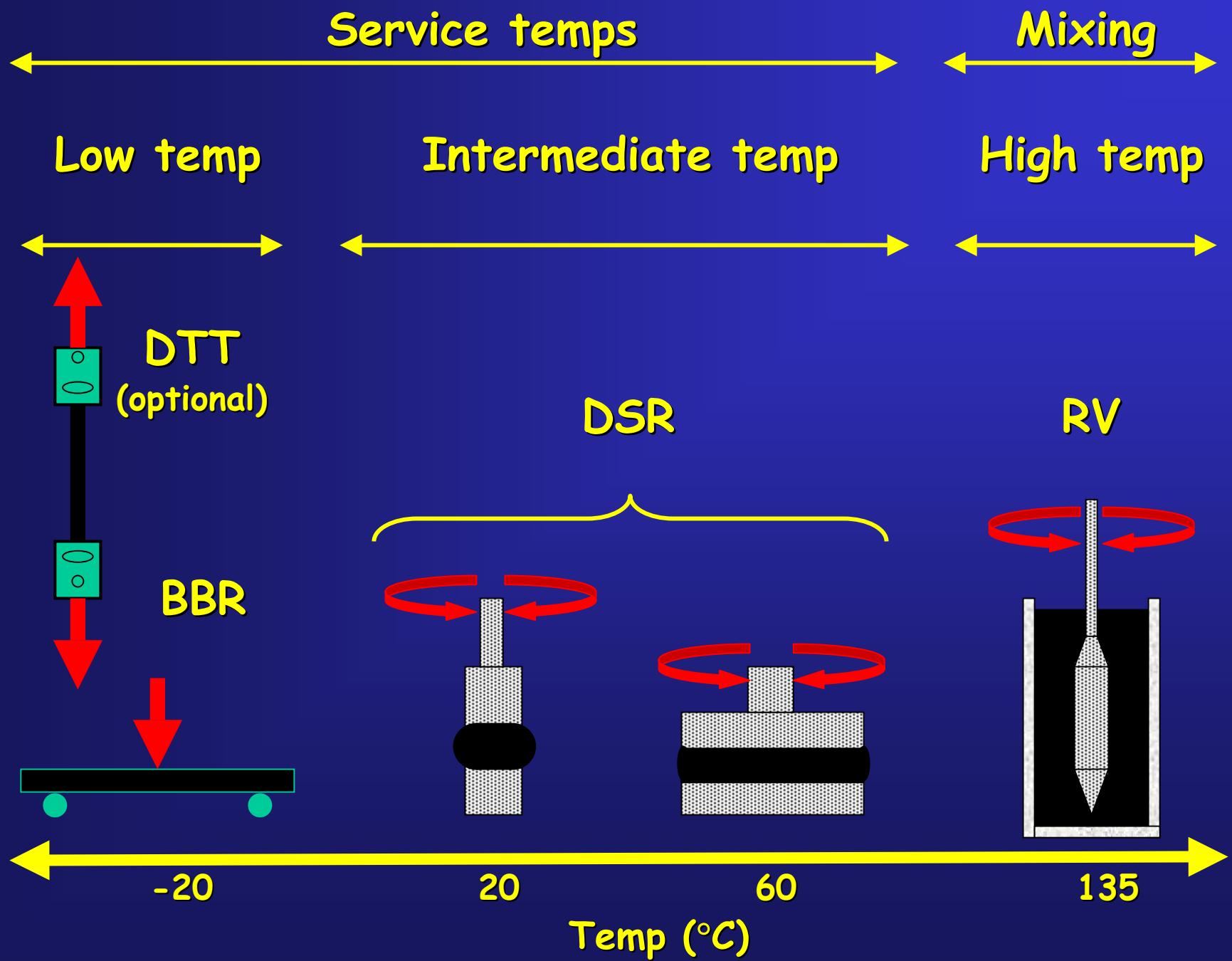
Pavement Temps



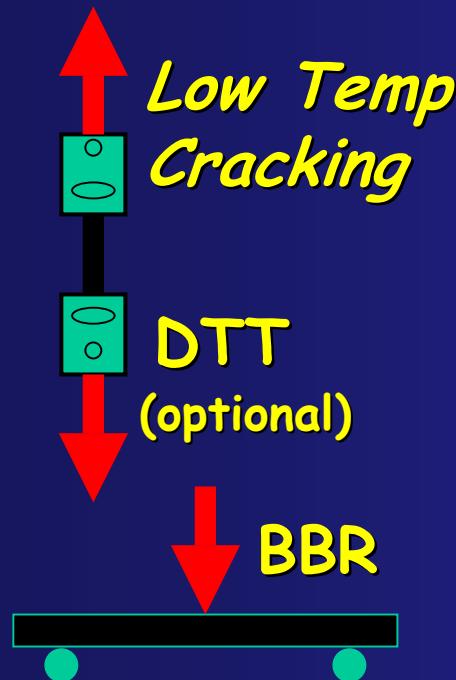
PG Binders



PG Concept & Equipment



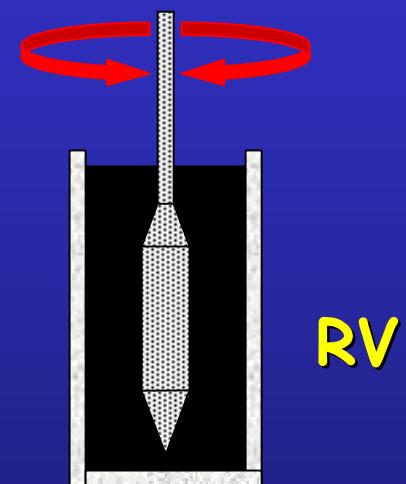
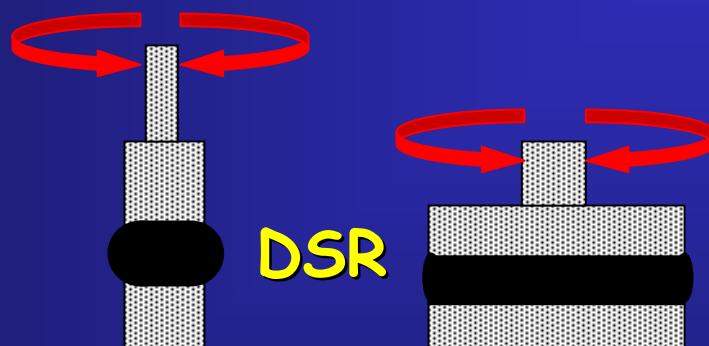
PG Spec Testing



*Fatigue
Cracking*

Rutting

Pumpability



Age Conditioning

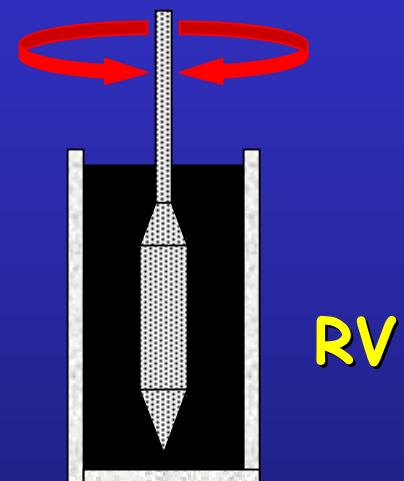
No aging

RTFO (Short Term)

PAV (Long Term)

PG Spec Testing

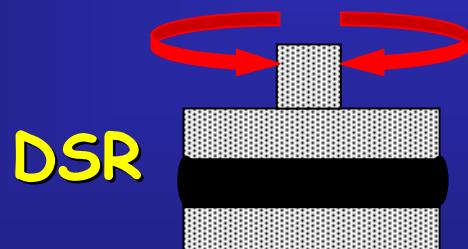
Pumpability



<i>Age Conditioning</i>	
<i>No aging</i>	✓
<i>RTFO (Short Term)</i>	
<i>PAV (Long Term)</i>	

PG Spec Testing

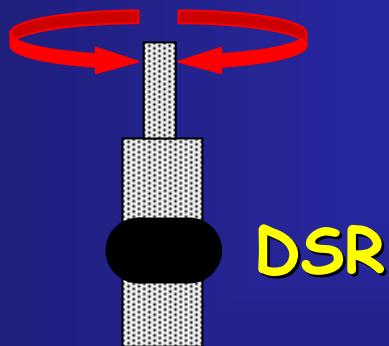
Rutting



Age Conditioning	
<i>No aging</i>	✓
<i>RTFO (Short Term)</i>	✓
<i>PAV (Long Term)</i>	

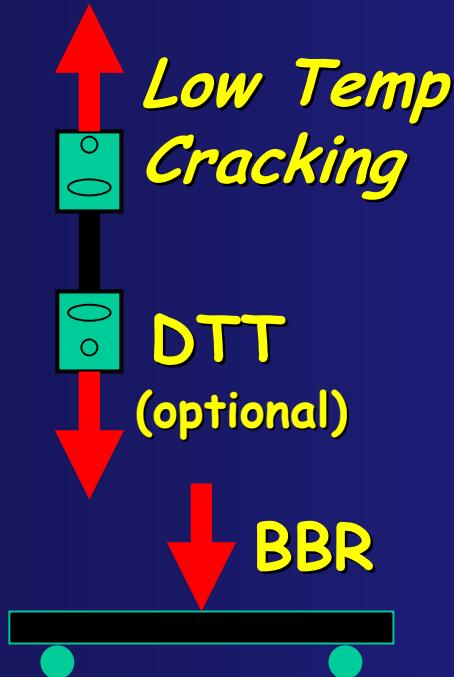
PG Spec Testing

*Fatigue
Cracking*



<i>Age Conditioning</i>	
<i>No aging</i>	
<i>RTFO (Short Term)</i>	✓
<i>PAV (Long Term)</i>	✓

PG Spec Testing

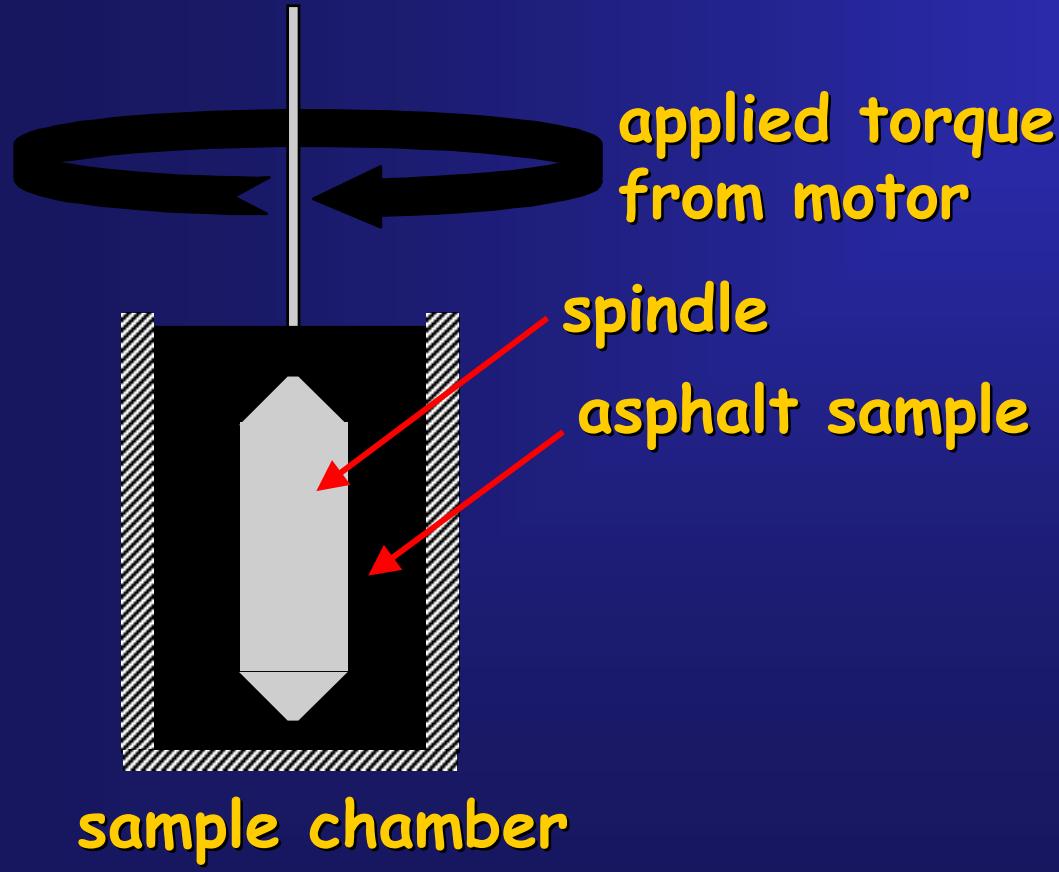


Age Conditioning	
<i>No aging</i>	
<i>RTFO (Short Term)</i>	✓
<i>PAV (Long Term)</i>	✓

Rotational Viscometer (RV)

AASHTO T48 , ASTM D4402

Evaluate consistency for pumping

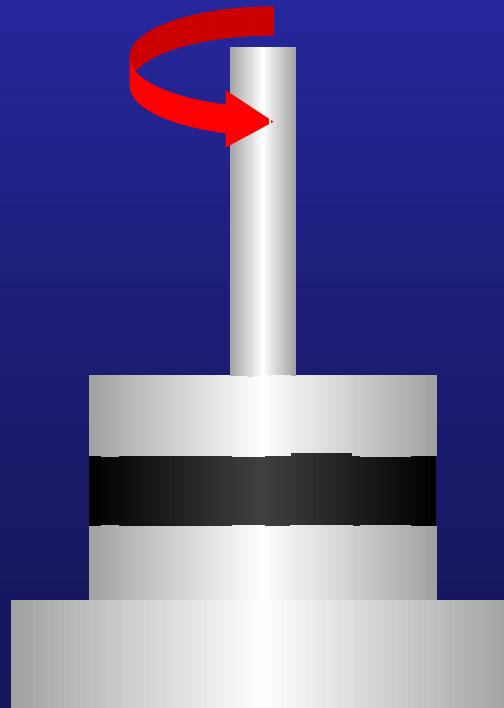


- 135°C
- Apply torque
- Measure rotational speed
- Calculate viscosity

Dynamic Shear Rheometer (DSR)

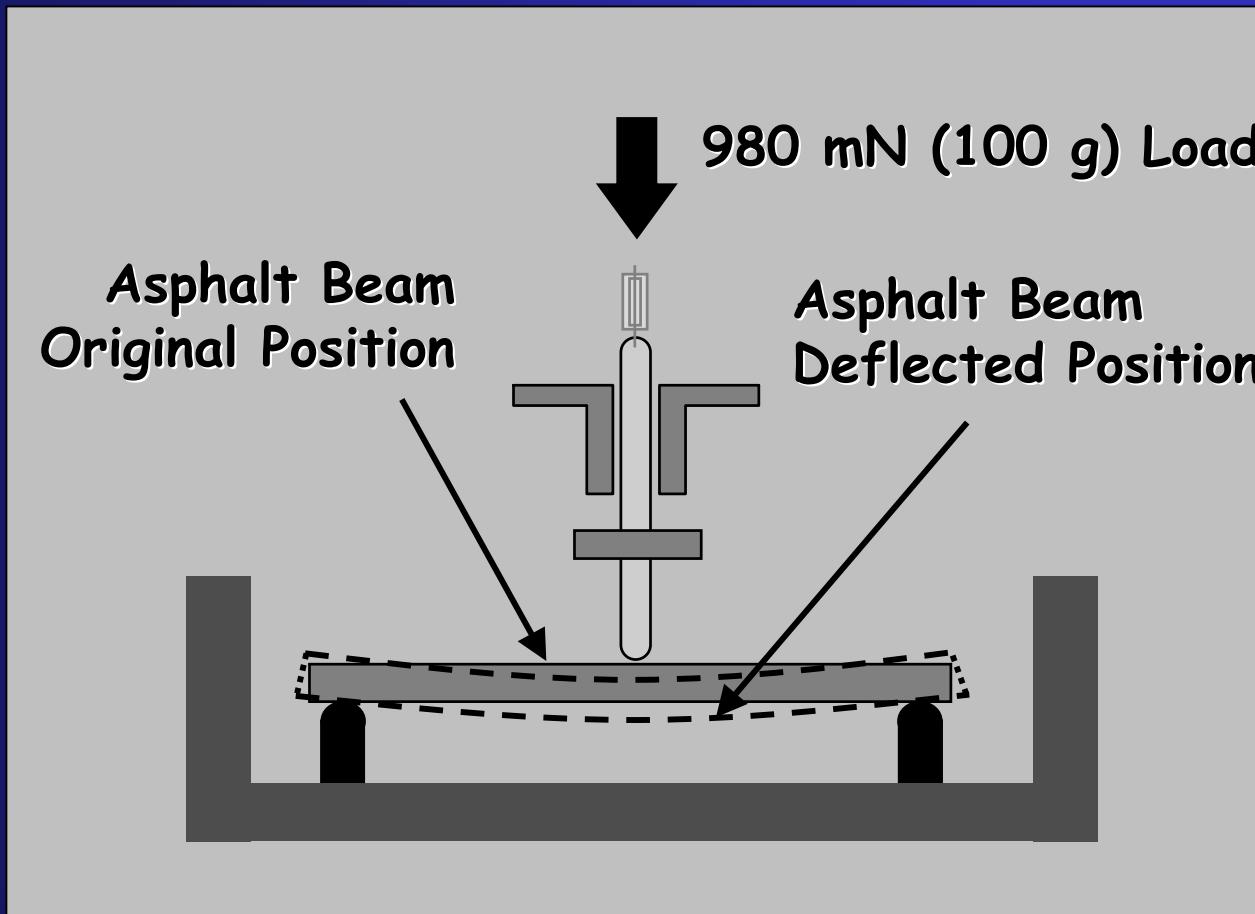
Evaluate viscoelastic properties of asphalt

- Apply an oscillating shear stress, τ
- Measure shear strain, γ
- Measure phase lag, δ
- Intermediate to high temps
- Complex Modulus =
$$\frac{\tau_{\max}}{\gamma_{\max}}$$



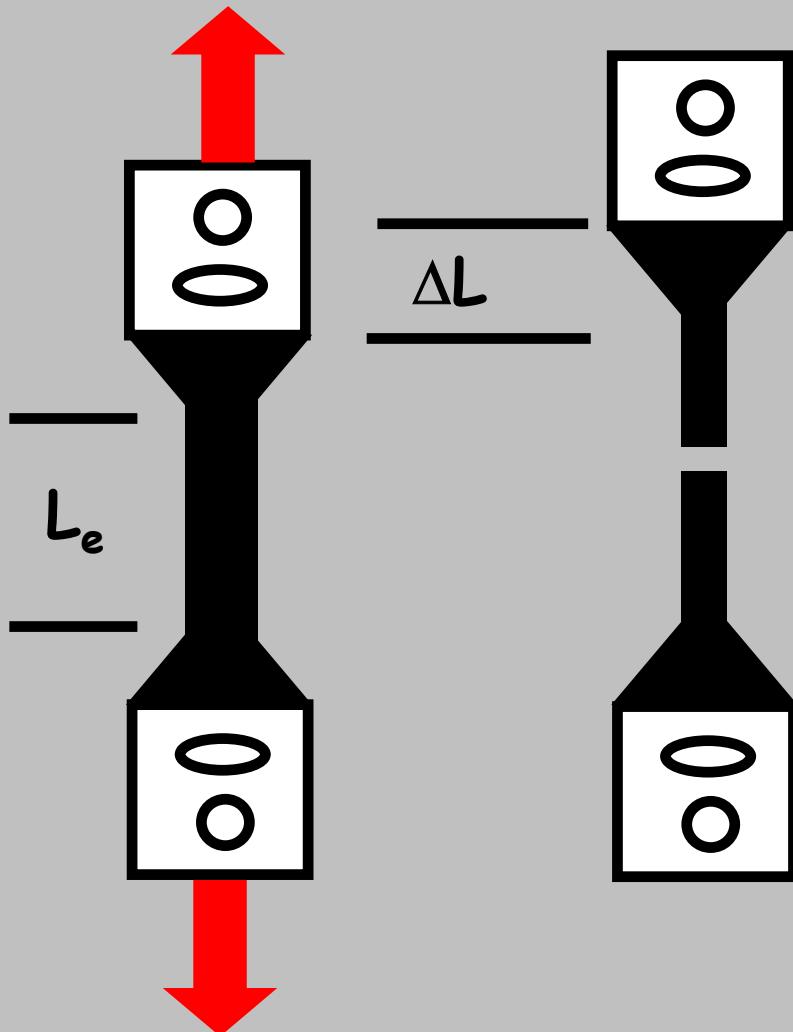
Bending Beam Rheometer (BBR)

Evaluate low temp creep stiffness of asphalt



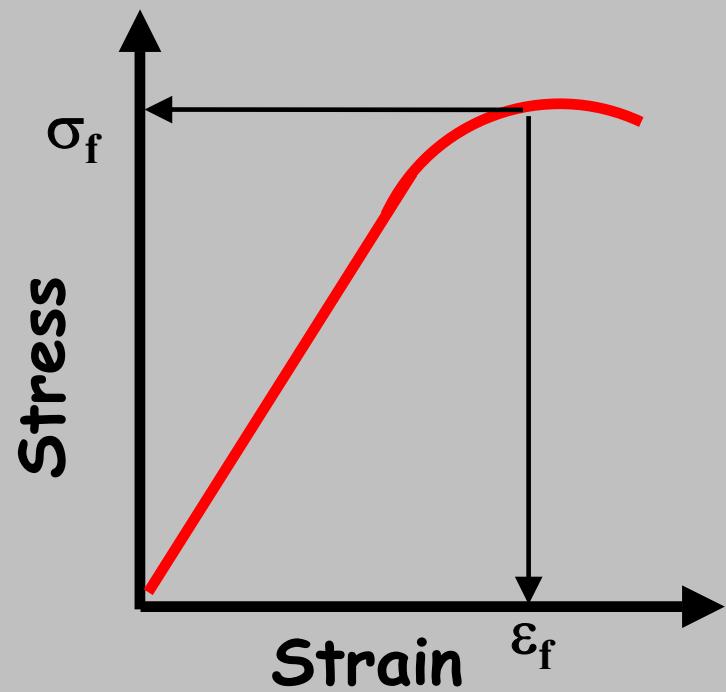
Direct Tension Test (DTT)

Load, P



$$\text{Stress } (\sigma) = \frac{P}{A}$$

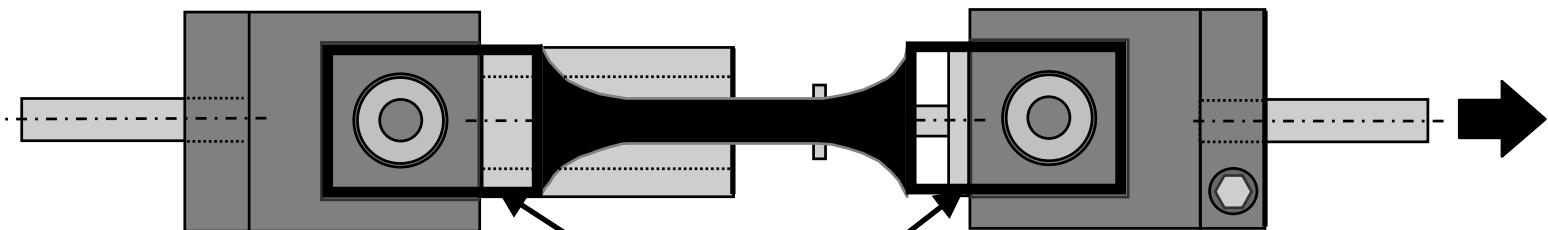
$$\text{Strain } (\varepsilon) = \frac{\Delta L}{L_e} \times 100$$



(optional)

Direct Tension Test

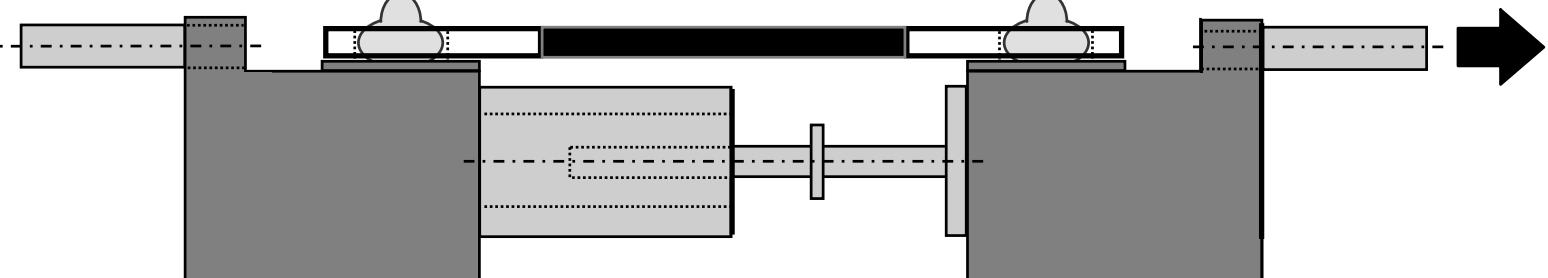
Top View



ball joint pins

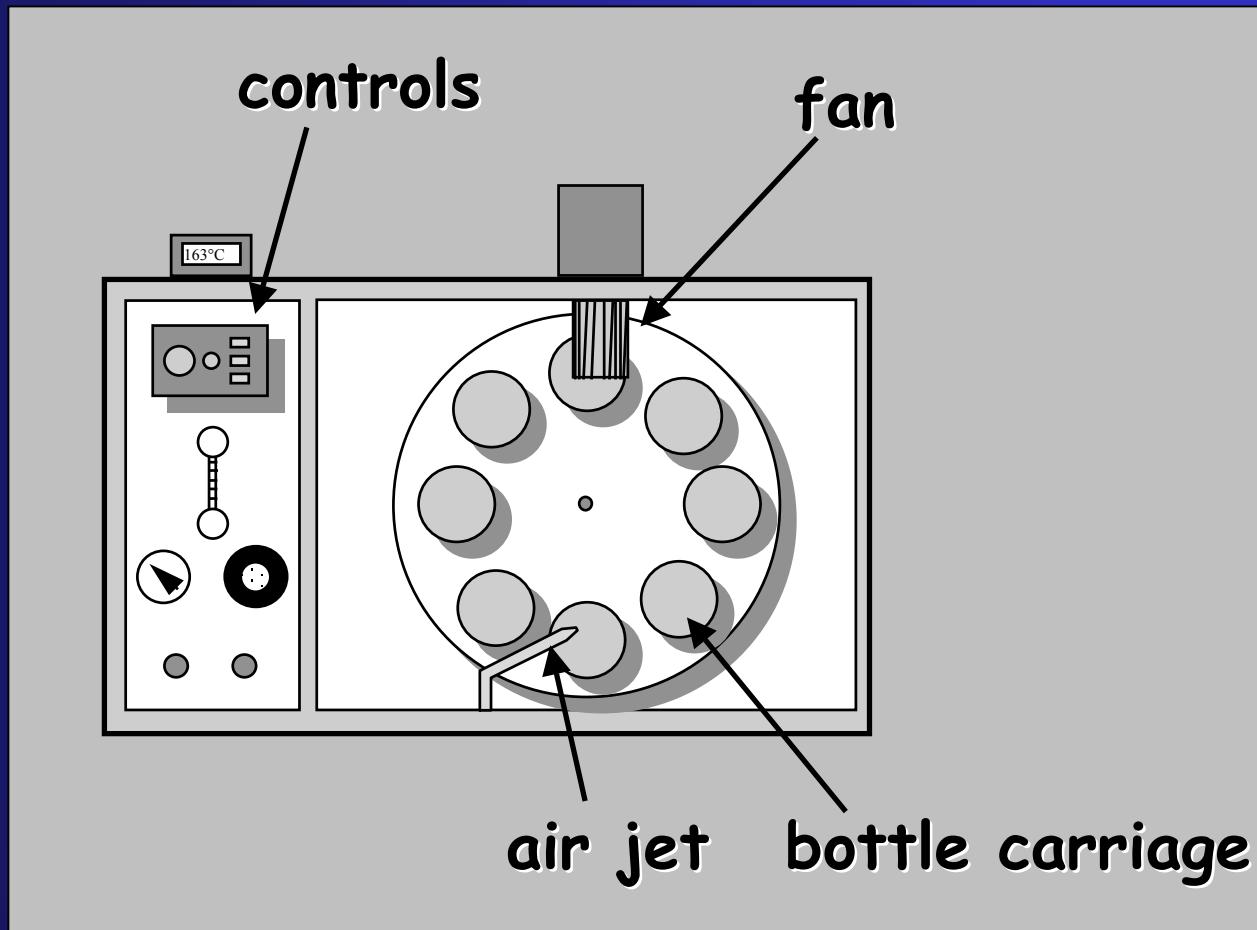
specimen inserts

Side View

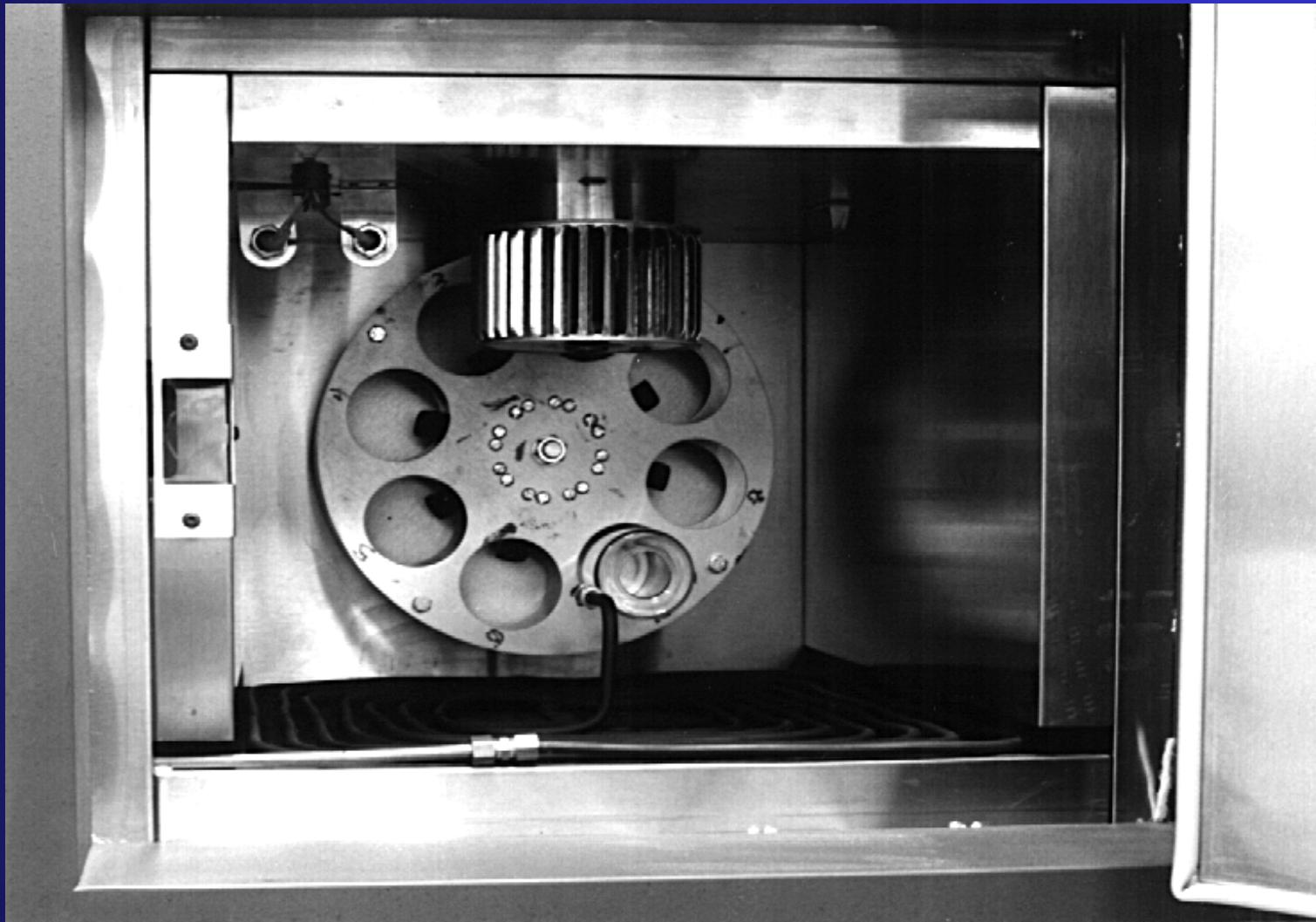


Rolling Thin Film Oven (RTFO)

AASHTO T240, ASTM D2872



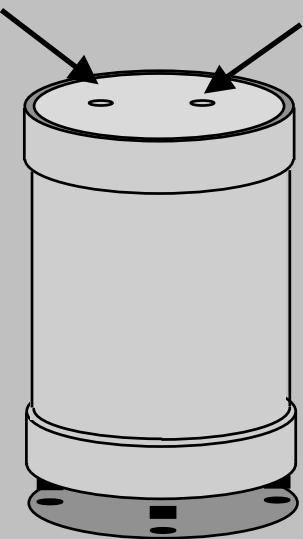
Rolling Thin Film Oven (RTFO)



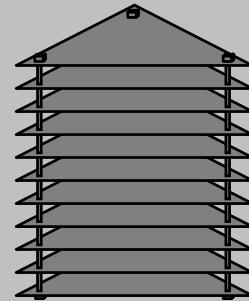
Pressure Aging Vessel (PAV)

AASHTO R28

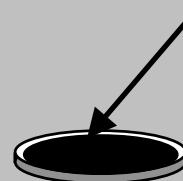
air
pressure



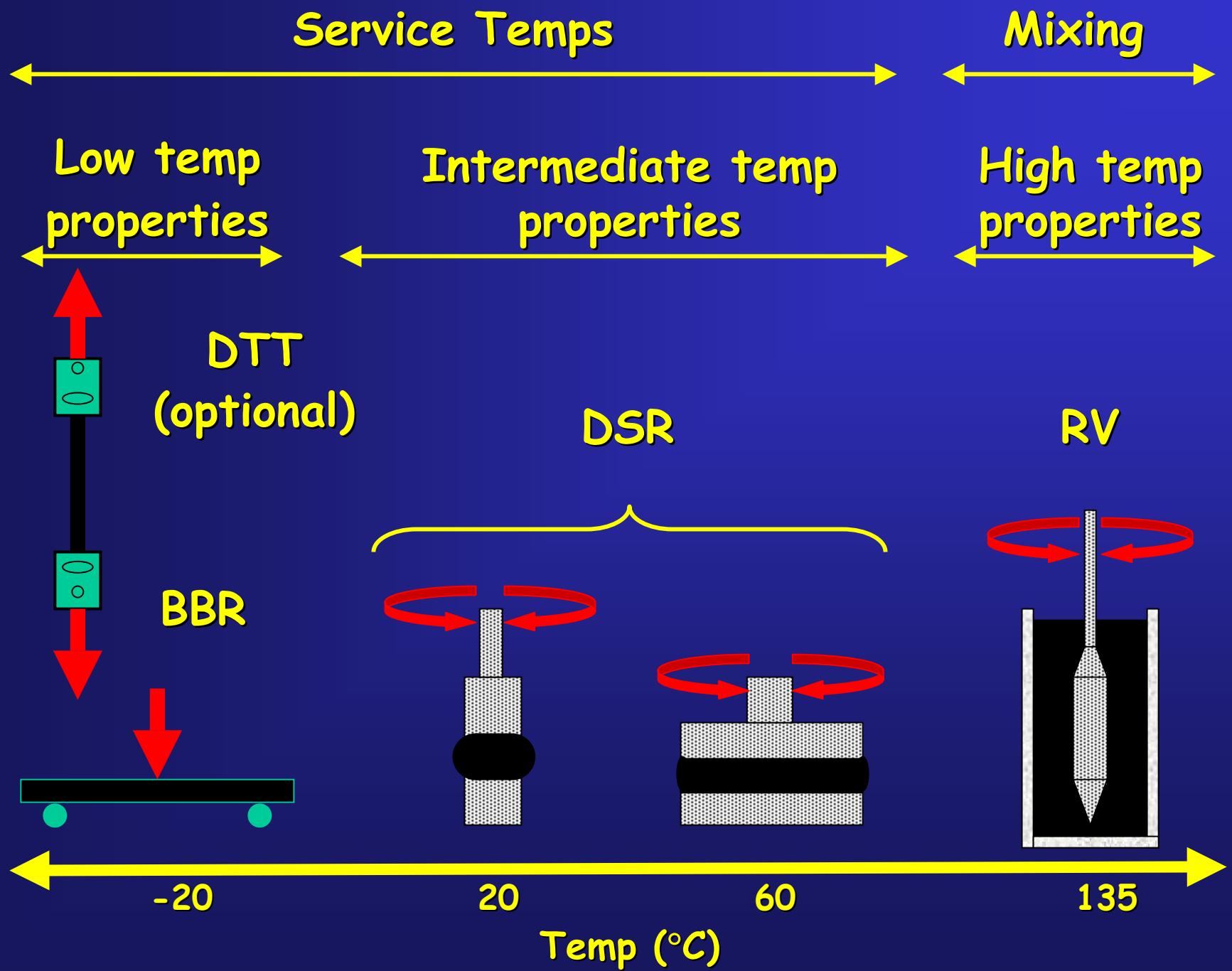
temperature
probe



asphalt
binder
(after
RTFO)



pressure vessel sample rack sample pan



PG Specification -

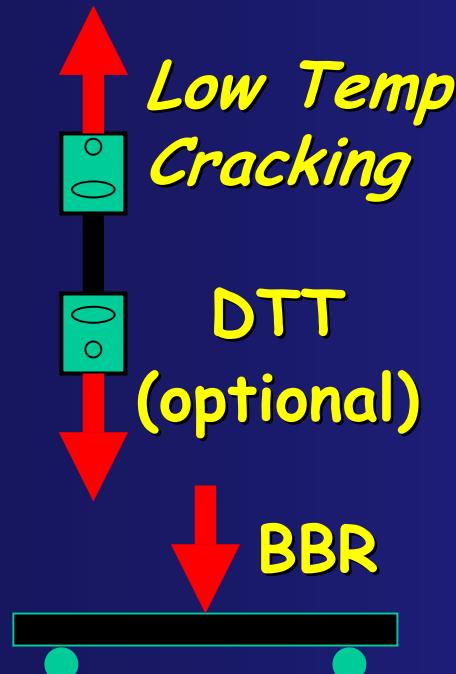
AASHTO M320-04

Current PG Spec - Handout

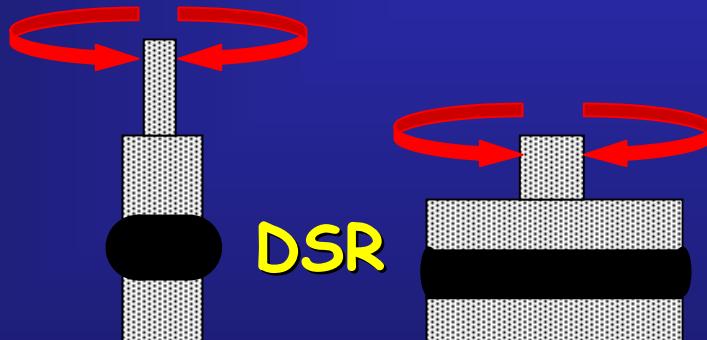
Tests Used in PG Binder System

- Safety - COC Flash Point
- Pumpability - RV at High Temp (135°C)
- Rutting - DSR at High Temps
 - Original & RTFOT-Aged; ie, 2 "conditions"
- Fatigue Cracking - DSR at Intermediate Temps
 - RTFOT \Rightarrow PAV-Aged; ie, 1 "condition"
- Low Temp Cracking - BBR & DTT (optional) at Low Temps
 - RTFOT \Rightarrow PAV-Aged; 1 "condition"

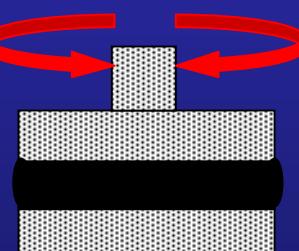
PG Spec Testing



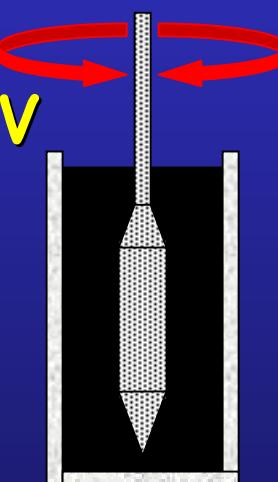
*Fatigue
Cracking*



Rutting



Pumpability

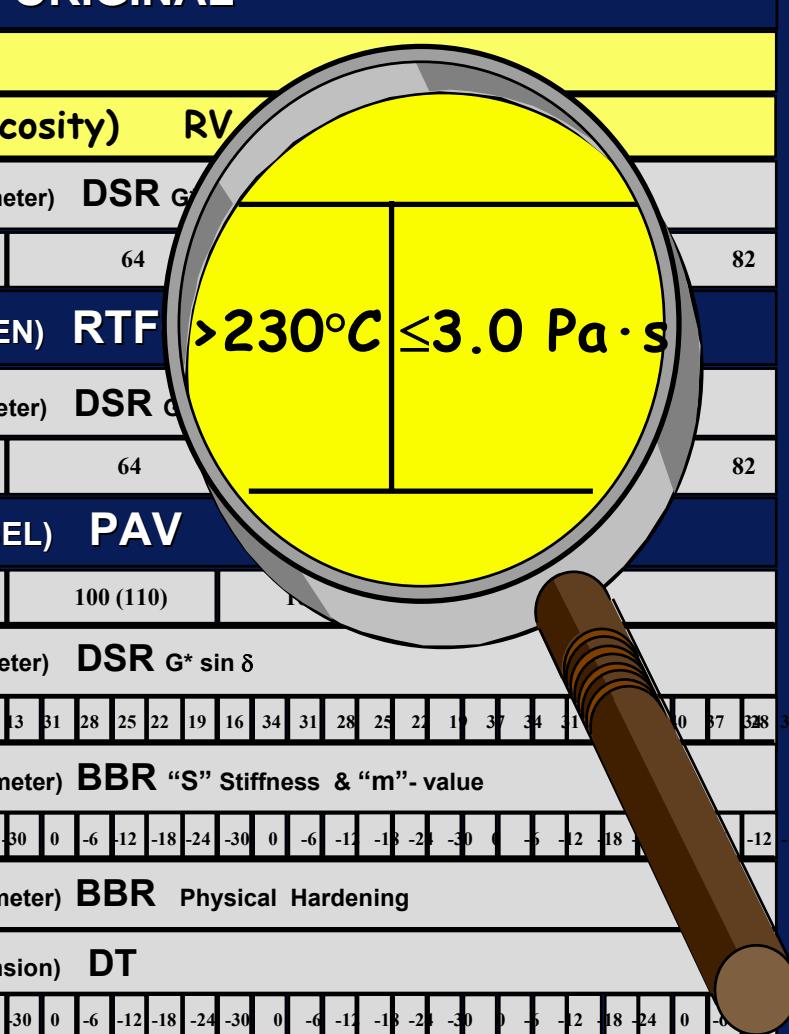


Safety & Pumpability

CEC

Avg 7-day Max, °C	PG 46	PG 52	PG 58	PG 64	PG 70	PG 76	PG 82
1-day Min, °C	-34 -40 -46 -10 -10 -22 -28 -34 -0 -6 -16 -22 -28 -34 -40 -10 -16 -22 -28 -34 -40 -10 -10 -22 -28 -3 -40 -10 -15 -22 -18 -4 -10 16 -22	-28 -34					
ORIGINAL							
≥ 230 °C	(Flash Point) FP						
≤ 3 Pa·s @ 135 °C	(Rotational Viscosity) RV						
≥ 1.00 kPa	(Dynamic Shear Rheometer) DSR G*						
	46	52	58	64			82
(ROLLING THIN FILM OVEN) RTF							
≥ 2.20 kPa	(Dynamic Shear Rheometer) DSR G* sin δ						
	46	52	58	64			82
(PRESSURE AGING VESSEL) PAV							
20 Hours, 2.07 MPa	90	90	100	100	100 (110)		
≤ 5000 kPa	(Dynamic Shear Rheometer) DSR G* sin δ						
	10	7	4	25	22	19	1
S ≤ 300 MPa m ≥ 0.300	(Bending Beam Rheometer) BBR "S" Stiffness & "m"- value						
	-24	-30	-30	0	-6	-12	-18
Report Value	(Bending Beam Rheometer) BBR Physical Hardening						
≥ 1.00 %	(Direct Tension) DT						
O → O	-24	-30	-30	0	-6	-12	-18
	-18	-24					

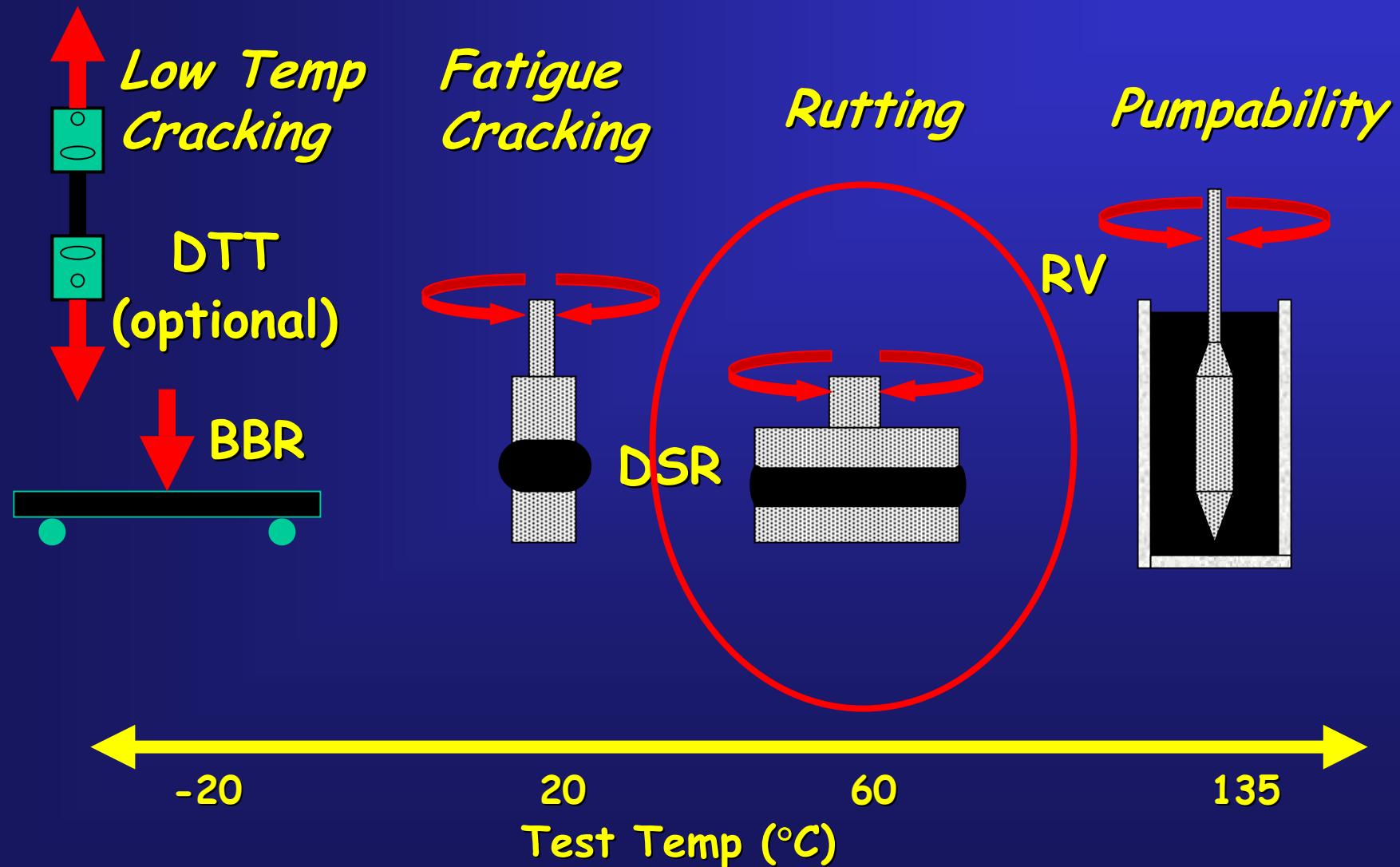
First Checks



Pumpability

- During construction a contractor must be able to pump the binder.
 - Viscosity (η) \leq 3 Pa·s at 135°C for the unaged binder

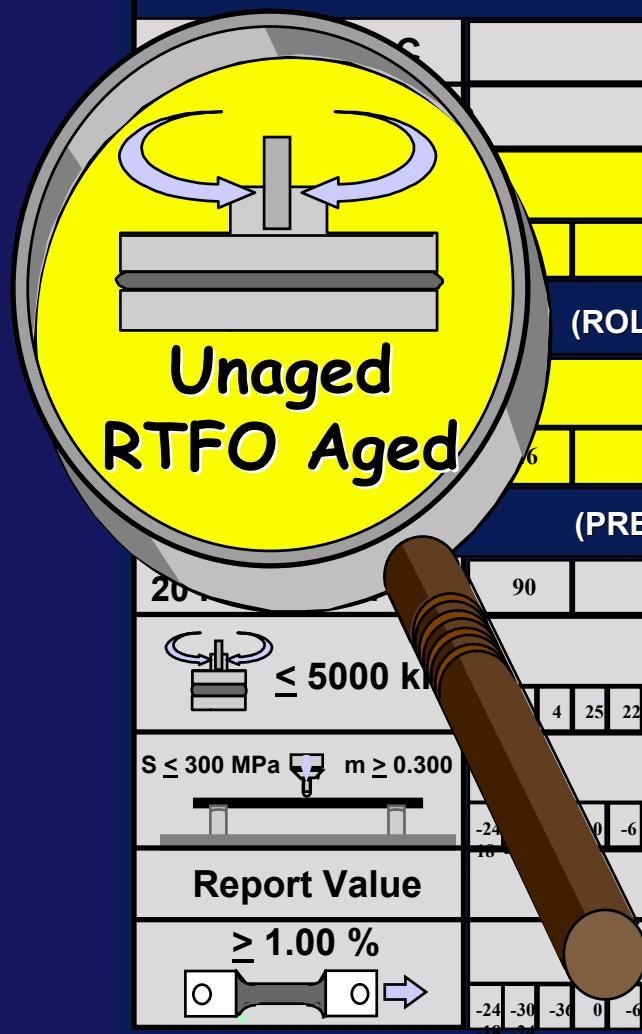
PG Spec Testing



Rutting/Permanent Deformation

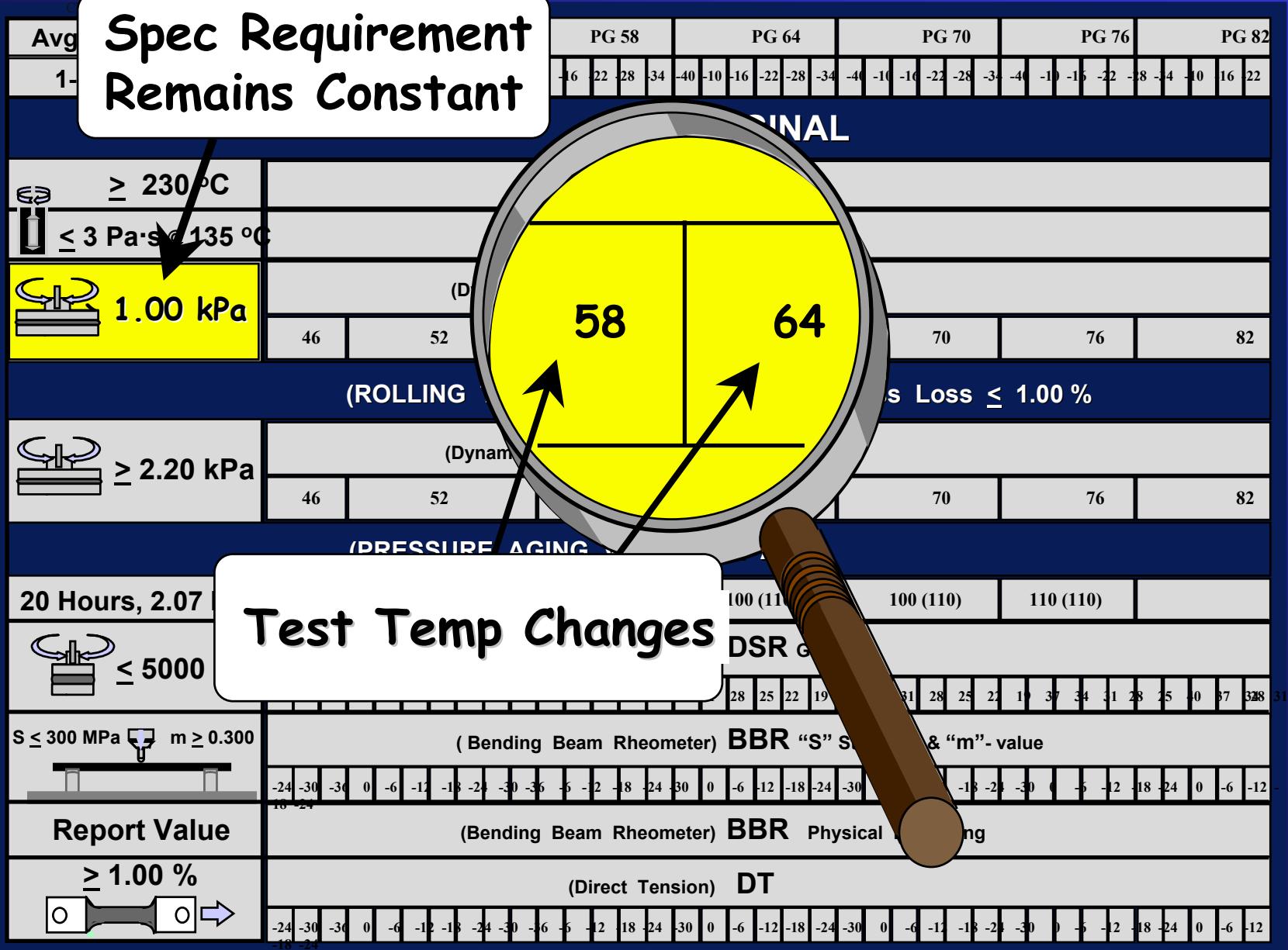
CEC

Avg 7-day Max, °C	PG 46	PG 52	PG 58	PG 64	PG 70	PG 76	PG 82
1-day Min, °C	-34 -40 -46 -10 -10 -22 -28 -34 -0 -6 -16 -22 -28 -34 -40 -10 -16 -22 -28 -34 -40 -10 -10 -22 -28 -3 -40 -10 -15 -22 -18 -4 -10 16 -22	-28 -34					
ORIGINAL							
(Flash Point) FP							
(Rotational Viscosity) RV							
(Dynamic Shear Rheometer) DSR $G^*/\sin \delta$							
	52	58	64	70	76	82	
(ROLLING THIN FILM OVEN) RTFO Mass Loss $\leq 1.00\%$							
(Dynamic Shear Rheometer) DSR $G^*/\sin \delta$							
	6	52	58	64	70	76	82
(PRESSURE AGING VESSEL) PAV							
200 kPa	90	90	100	100	100 (110)	100 (110)	110 (110)
 ≤ 5000 kPa	4	25	22	19	1	13	10
	7	25	22	9	6	13	31
	31	28	25	22	19	16	34
	31	28	25	22	19	37	34
	31	28	25	22	19	31	28
	25	22	19	16	34	31	28
	19	16	34	31	28	37	34
	16	34	31	28	37	34	31
	34	31	28	37	34	31	28
	31	28	37	34	31	28	37
	28	37	34	31	28	37	34
	37	34	31	28	37	34	31
	34	31	28	37	34	31	28
	31	28	37	34	31	28	37
(Dynamic Shear Rheometer) DSR $G^*/\sin \delta$							
	4	25	22	19	1	13	10
	7	25	22	9	6	13	31
	31	28	25	22	19	16	34
	31	28	25	22	19	37	34
	25	22	19	16	34	31	28
	19	16	34	31	28	37	34
	16	34	31	28	37	34	31
	34	31	28	37	34	31	28
	31	28	37	34	31	28	37
	28	37	34	31	28	37	34
	37	34	31	28	37	34	31
	34	31	28	37	34	31	28
	31	28	37	34	31	28	37
(Bending Beam Rheometer) BBR "S" Stiffness & "m"- value							
	-24	-30	-30	-6	-12	-18	-24
	-30	-6	-12	-18	-24	-30	0
	-6	-12	-18	-24	-30	0	-6
	-12	-18	-24	-30	0	-6	-12
	-18	-24	-30	0	-6	-12	-18
	-24	0	-6	-12	-18	-24	0
	0	-6	-12	-18	-24	0	-6
	-6	-12	-18	-24	0	-6	-12
	-12	-18	-24	0	-6	-12	-18
	-18	-24	0	-6	-12	-18	-24
	-24	0	-6	-12	-18	-24	0
(Bending Beam Rheometer) BBR Physical Hardening							
	-24	-30	-30	-6	-12	-18	-24
	-30	-6	-12	-18	-24	-30	0
	-6	-12	-18	-24	-30	0	-6
	-12	-18	-24	-30	0	-6	-12
	-18	-24	-30	0	-6	-12	-18
	-24	0	-6	-12	-18	-24	0
	0	-6	-12	-18	-24	0	-6
	-6	-12	-18	-24	0	-6	-12
	-12	-18	-24	0	-6	-12	-18
	-18	-24	0	-6	-12	-18	-24
	-24	0	-6	-12	-18	-24	0
(Direct Tension) DT							
	-24	-30	-30	-6	-12	-18	-24
	-30	-6	-12	-18	-24	-30	0
	-6	-12	-18	-24	-30	0	-6
	-12	-18	-24	-30	0	-6	-12
	-18	-24	-30	0	-6	-12	-18
	-24	0	-6	-12	-18	-24	0
	0	-6	-12	-18	-24	0	-6
	-6	-12	-18	-24	0	-6	-12
	-12	-18	-24	0	-6	-12	-18
	-18	-24	0	-6	-12	-18	-24
	-24	0	-6	-12	-18	-24	0



How the PG Spec Works

Spec Requirement Remains Constant



Rutting/Permanent Deformation

Addressed by

$G^*/\sin \delta > 1.00 \text{ kPa}$ (unaged binder)

$G^*/\sin \delta \geq 2.20 \text{ kPa}$ (RTFO-aged binder)



For the early part
of the service life

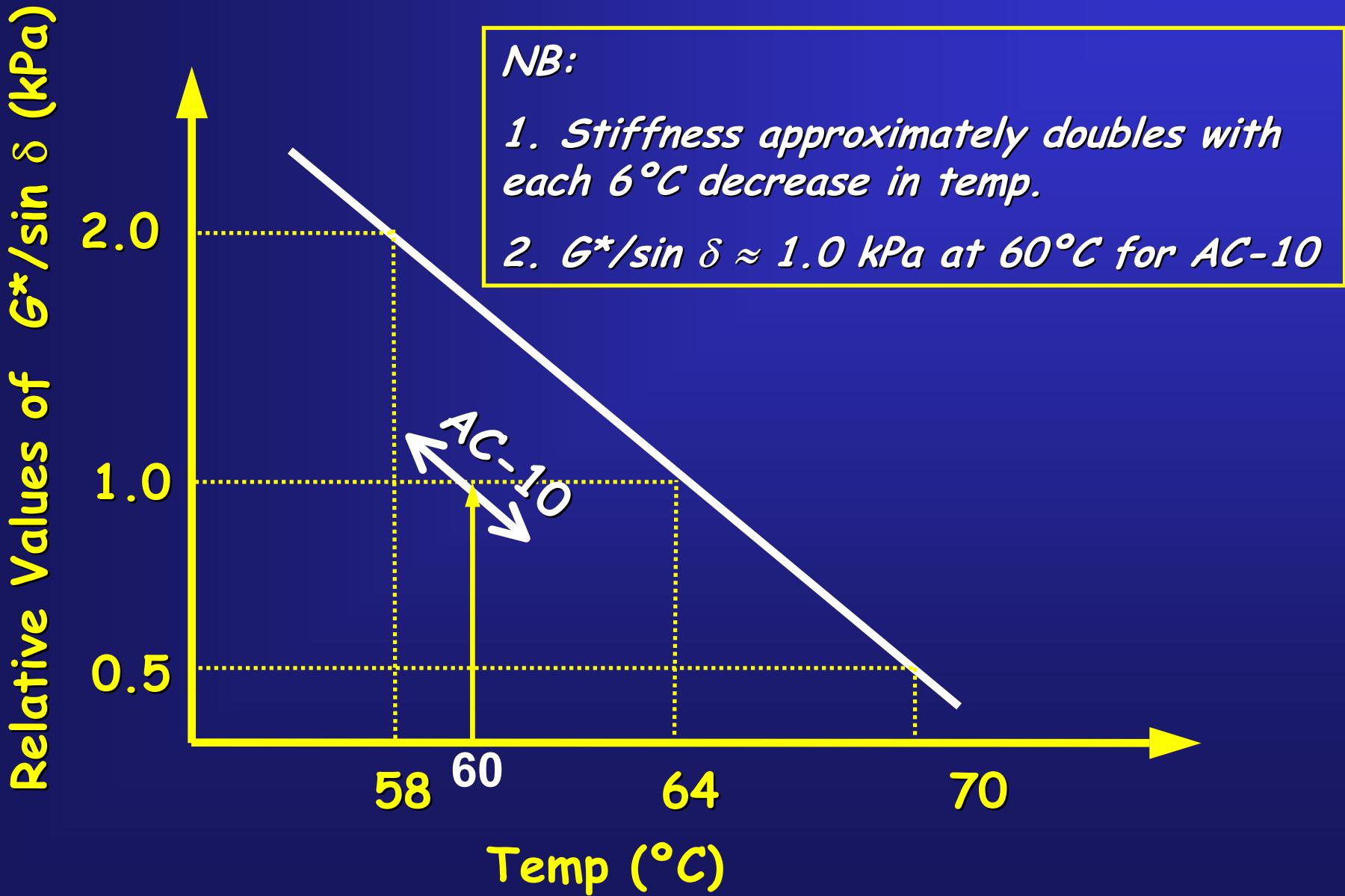
Mass Loss Spec

- Calculate mass loss after RTFO.

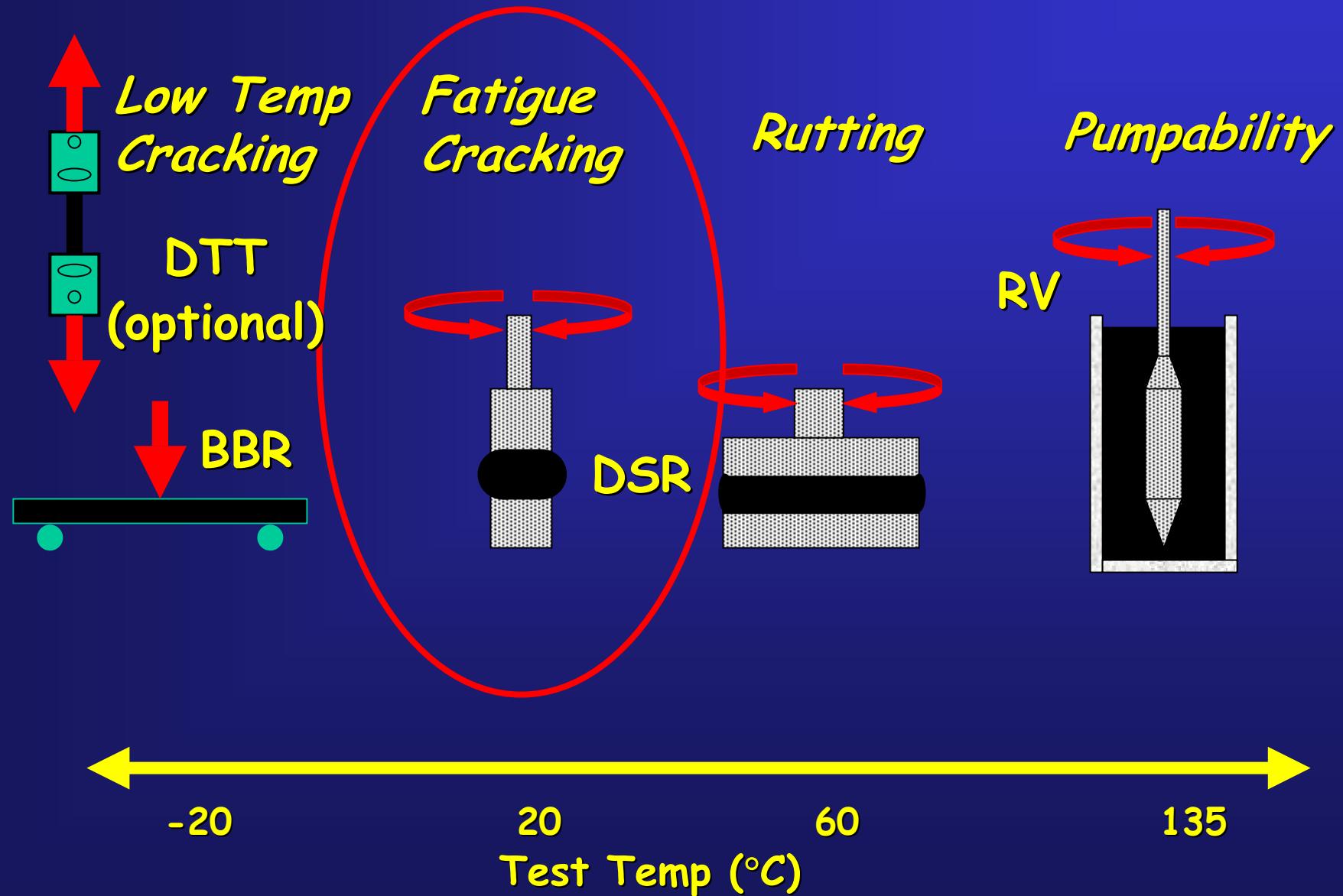
$$\text{Mass loss, \%} = \frac{\text{Original mass} - \text{Aged mass}}{\text{Original mass}} \times 100$$

- Mass Loss $\leq 1.0\%$

Establishing Grades - DSR Data



PG Spec Testing



Fatigue Cracking

Avg 7-day Max, °C	PG 46	PG 52	PG 58	PG 64	PG 70	PG 76	PG 82																			
1-day Min, °C	-34 -28	-40 -32	-46 -32	-10 -10	-10 -22	-28 -28	-34 -34	-40 -40	-10 -16	-16 -22	-28 -28	-34 -34	-40 -40	-10 -10	-10 -22	-28 -28	-3 -3	-40 -40	-10 -10	-15 -15	-22 -22	-18 -18	-4 -4	-10 -10	16 16	22 22

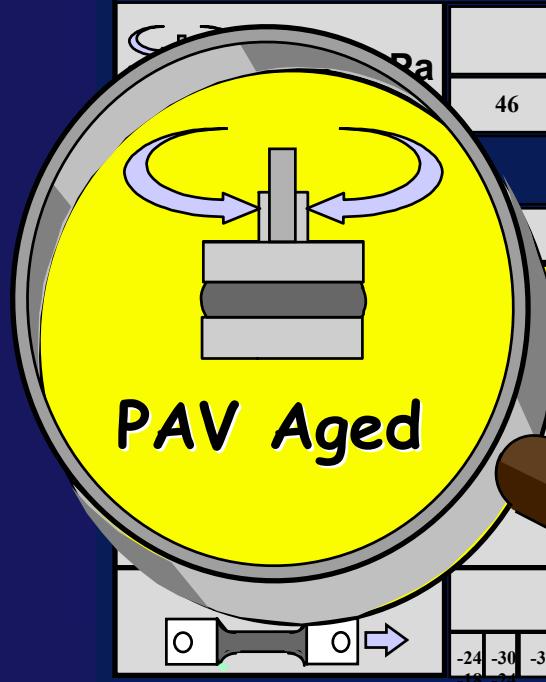
ORIGINAL

 $\geq 230 \text{ }^{\circ}\text{C}$	(Flash Point) FP
 $\leq 3 \text{ Pa}\cdot\text{s} @ 135 \text{ }^{\circ}\text{C}$	(Rotational Viscosity) RV
 $\geq 1.00 \text{ kPa}$	(Dynamic Shear Rheometer) DSR $\text{G}^*/\sin \delta$

(ROLLING THIN FILM OVEN) RTFO Mass Loss < 1.00 %

	(Dynamic Shear Rheometer)	DSR	$G^*/\sin \delta$
46	52	58	64
(PRESSURE AGING VESSEL) PAV			70
76	82		
88	100	108	108 (110)
108 (110)	110	110 (110)	110 (110)

(PRESSURE AGING VESSEL) PAV



90 **100** **100** **100 (110)** **100 (110)** **110 (110)**

(Dynamic Shear Rheometer) DSR $G^* \sin \delta$

25 22 19 16 13 10 7 26 22 9 6 13 31 28 25 22 19 16 34 31 28 25 22 19 37 34 1 28 25 0 87 328 31

(Bending Beam Rheometer) BBR "S" Stiffness & "m"- value

$$1 -18 -2 -30 -36 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 0 -6 -12 -18 -24 -30$$

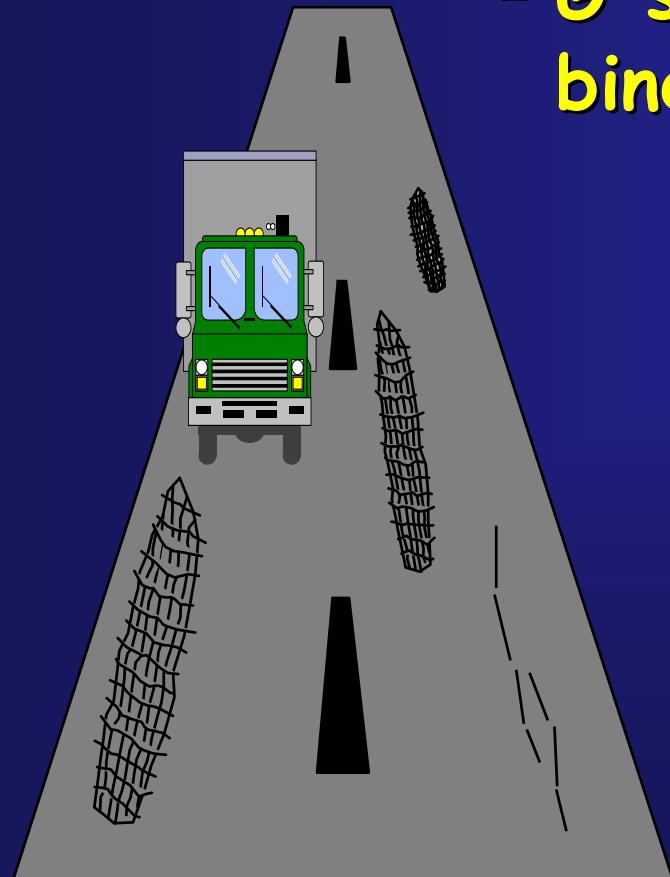
Ring Beam Rheometer) **BBR** Physical Hardening

(*Direct Tension*) DT

$$0 -6 -12 -18 -24 -30 \quad 0 -6 -12$$

Fatigue Cracking

- Addressed by stiffness at intermediate temp
 - $G^* \sin \delta$ on RTFO & PAV-aged binder < 5000 kPa



For later part of
pavement service life

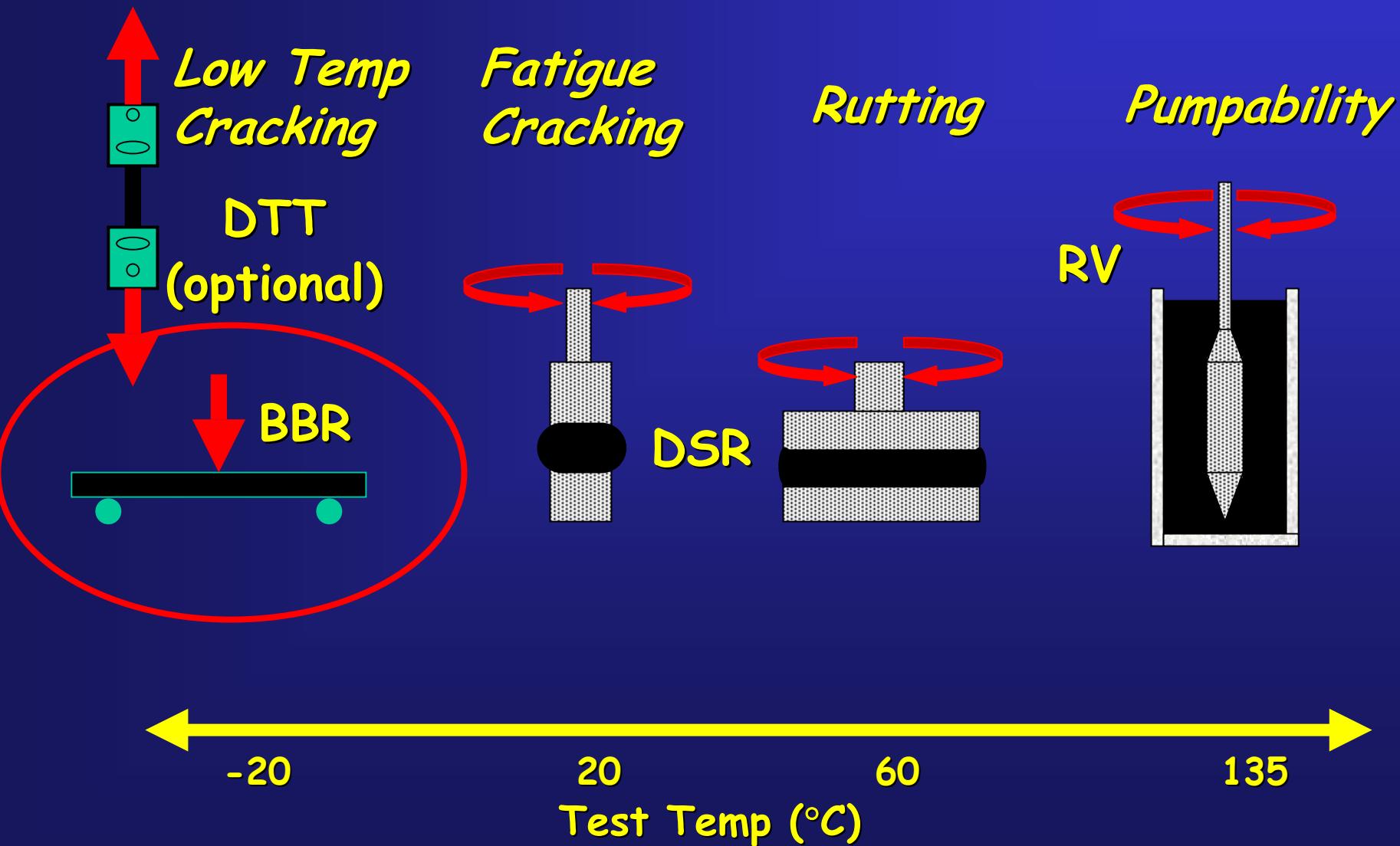
Fatigue Testing

- Long-term performance problem
- Use aged binder
 - Short-term aging (RTFO) + Long-term aging (PAV)

Notes on the Spec

- Assumed strain controlled distress (thin HMA)
- Initially a maximum of 3 MPa
 - Over 50% of binders tested failed
 - Raised to max of 5 MPa; 15% of binders failed
- Basis for limiting to 5 MPa

PG Spec Testing

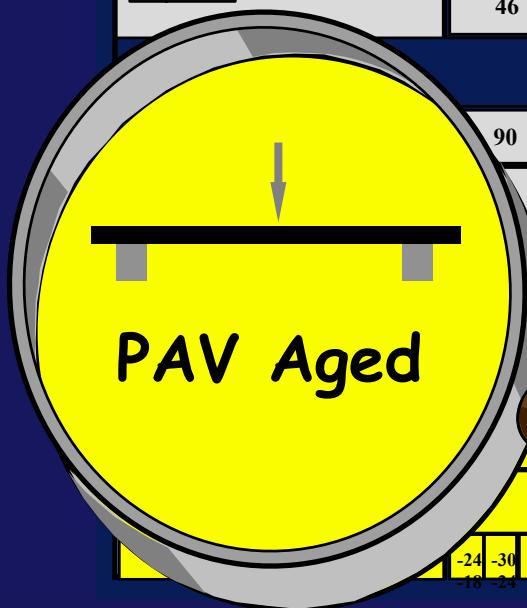


Low Temp Cracking

CEC

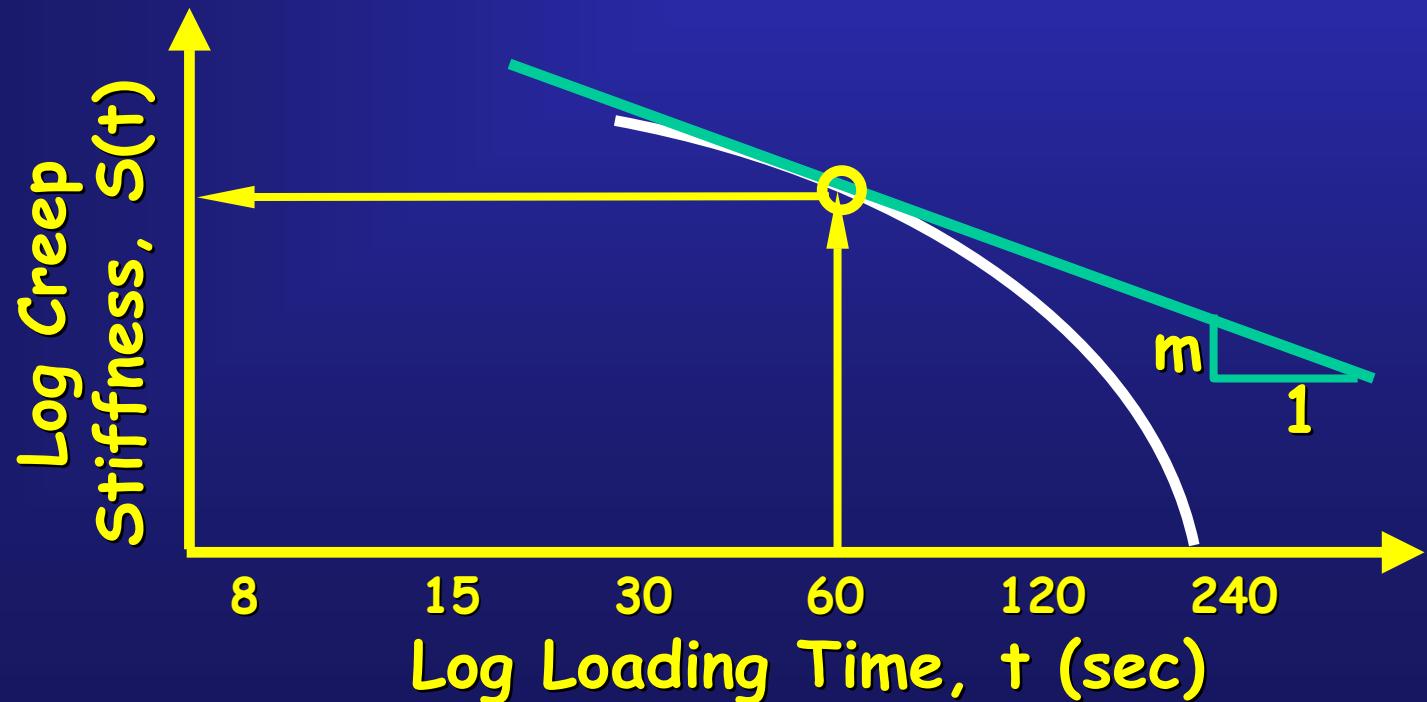
Avg 7-day Max, °C	PG 46	PG 52	PG 58	PG 64	PG 70	PG 76	PG 82
1-day Min, °C	-34 -40 -46 -10 -10 -22 -28 -34 -0 -6 -16 -22 -28 -34 -40 -10 -16 -22 -28 -34 -40 -10 -10 -22 -28 -3 -40 -10 -15 -32 -38 -4 -10 16 -22	-28 -34					
ORIGINAL							
 ≥ 230 °C	(Flash Point) FP						
 ≤ 3 Pa·s @ 135 °C	(Rotational Viscosity) RV						
 ≥ 1.00 kPa	(Dynamic Shear Rheometer) DSR G*/sin δ						
	46	52	58	64	70	76	82
(ROLLING THIN FILM OVEN) RTFO Mass Loss ≤ 1.00 %							
 ≥ 2.20 kPa	(Dynamic Shear Rheometer) DSR G*/sin δ						
	46	52	58	64	70	76	82
(PRESSURE AGING VESSEL) PAV							
	90	90	100	100	100 (110)	100 (110)	110 (110)
(Dynamic Shear Rheometer) DSR G* sin δ							
	25	22	19	1	13	10	7
(Bending Beam Rheometer) BBR "S" Stiffness & "m"- value							
	6	-11	-18	-24	-30	-36	-5
(Beam Rheometer) BBR Physical Hardening							
	-2	-8	-24	30	0	-6	-12
(Tension) DT							
	-24	-30	-30	0	-6	-12	-18
(Tension) DT							
	-18	-24	-24	-30	0	-6	-12

PAV Aged

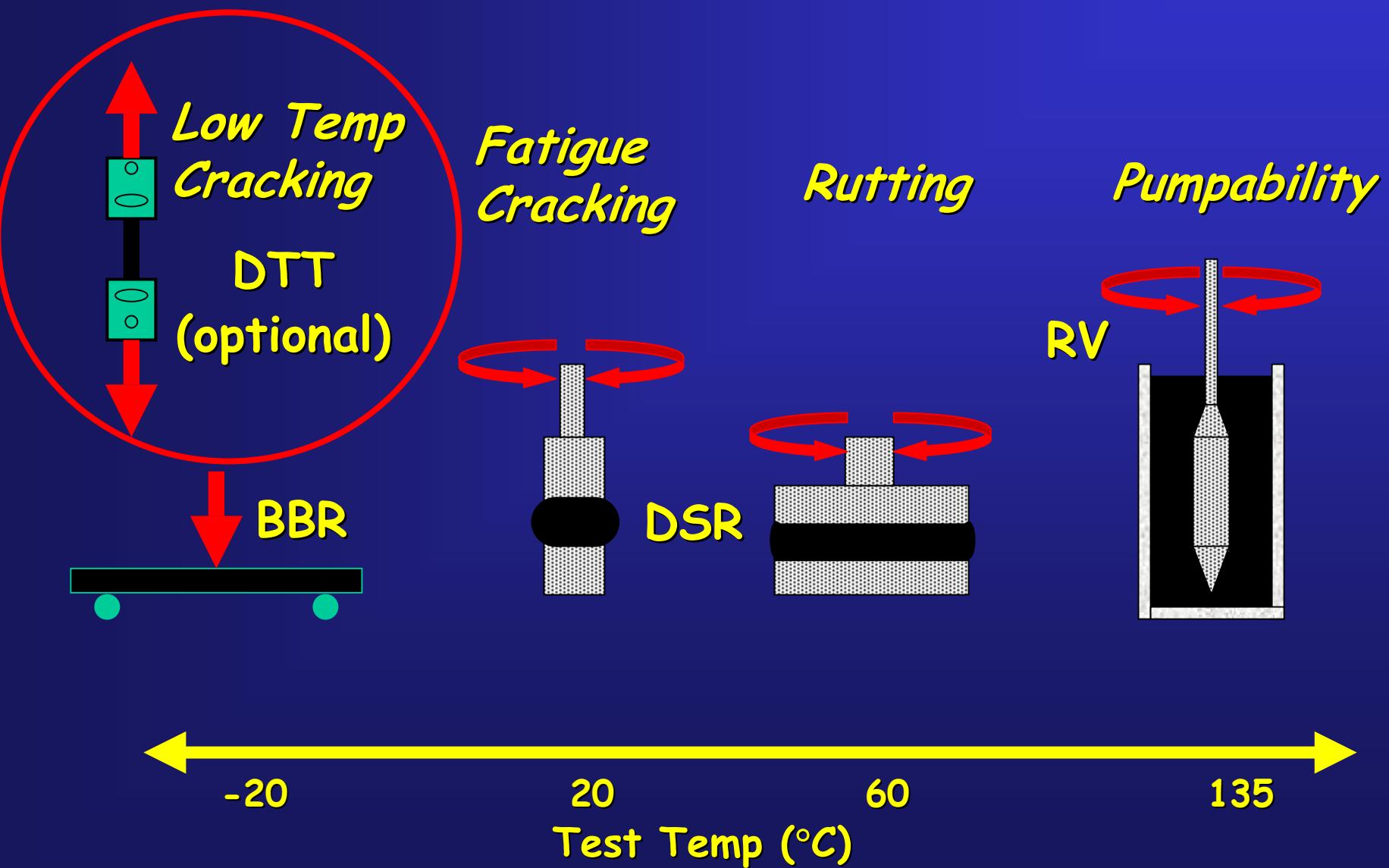


Bending Beam Rheometer

- Evaluates low temp stiffness
 - Creep stiffness, $S(t)$
 - Slope of log creep stiffness curve, "m-value"



PG Spec Testing



Low Temp Cracking

CEC

Avg 7-day Max, °C	PG 46	PG 52	PG 58	PG 64	PG 70	PG 76	PG 82																																
1-day Min, °C	-34 -28	-40 -34	-46 -40	-10 -16	-10 -16	-22 -28	-28 -34	-34 -40	-10 -16	-16 -22																													
ORIGINAL																																							
 ≥ 230 °C	(Flash Point) FP																																						
 ≤ 3 Pa·s @ 135 °C	(Rotational Viscosity) RV																																						
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	46	52	58	64	70	76	82																																
(PRESSURE AGING VESSEL) PAV																																							
	90	90	100	100	100 (110)	100 (110)	110 (110)																																
 →	(Dynamic Shear Rheometer) DSR G* sin δ																																						
	25	22	19	16	13	10	7	25	22	9	6	13	31	28	25	22	19	16	34	31	28	25	22	19	37	34	31	28	25	20	37	34	31	28	25	20	37	34	31
(Bending Beam Rheometer) BBR "S" Stiffness & "m"- value																																							
	0	-6	-12	-18	-24	-30	-36	-42	-48	-54	-60	-66	-72	-78	-84	-90	0	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	-30	-36	-42	-48	-54	-60	-66	-72	-78	-84	-90	
 ↗	(Bending Beam Rheometer) BBR Physical Hardening																																						
	24	-30	-36	0	-6	-12	-18	-24	-30	-36	-42	-48	-54	-60	-66	-72	-78	-84	-90	0	-6	-12	-18	-24	-30	-36	-42	-48	-54	-60	-66	-72	-78	-84	-90				
(Tension) DT																																							
	24	-30	-36	0	-6	-12	-18	-24	-30	-36	-42	-48	-54	-60	-66	-72	-78	-84	-90	0	-6	-12	-18	-24	-30	-36	-42	-48	-54	-60	-66	-72	-78	-84	-90				

PAV Aged

DTT (optional)

- σ_f (no spec criterion)
- $\varepsilon_f \geq 1.0\%$

Summary

- Evolution of binder grading systems
Penetration → Viscosity → PBA & PG
- PG
 - Fundamental properties measured.
 - Quantifies binder contributions to rutting, fatigue & low temp cracking.
 - Considers the effect of aging.

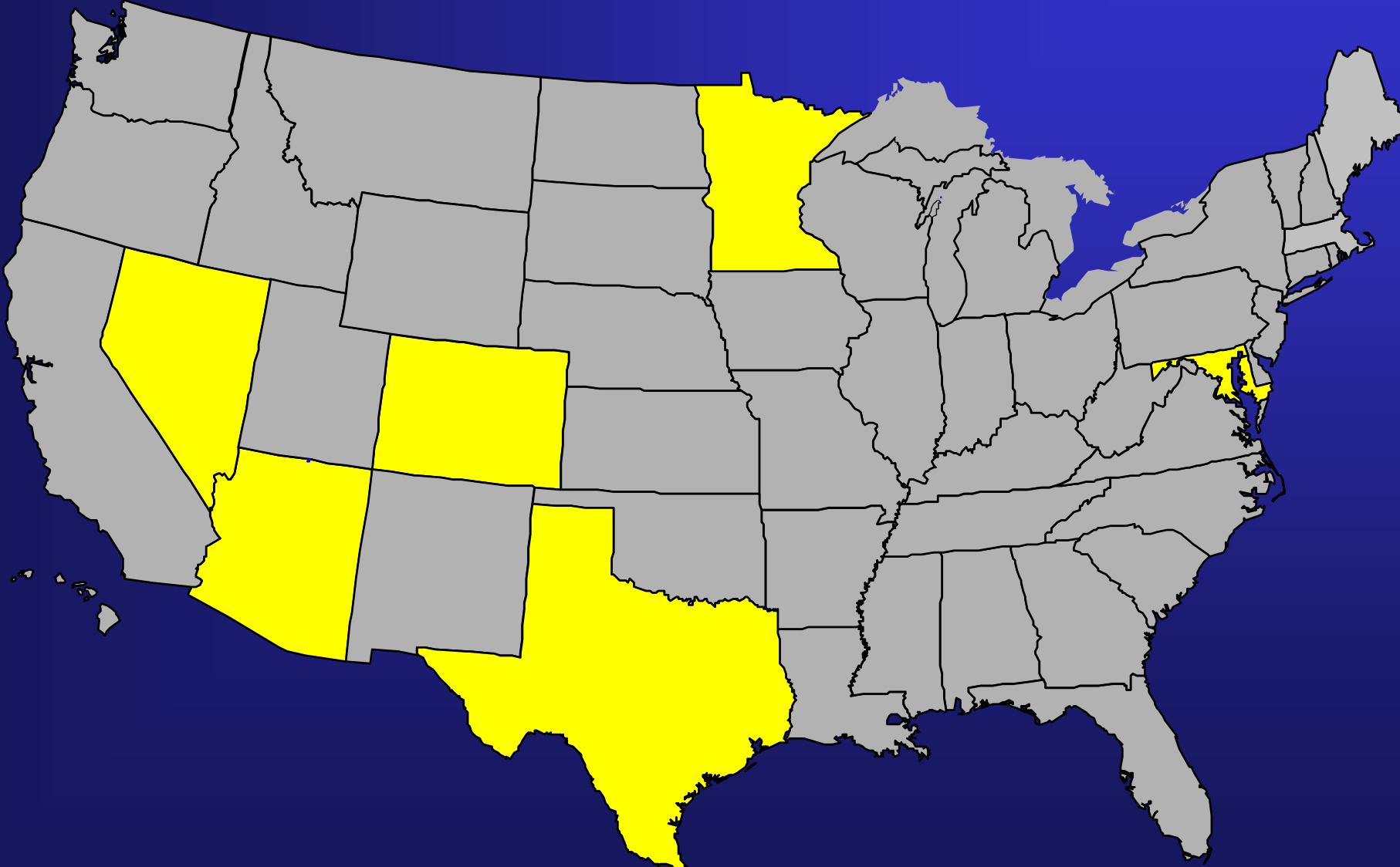
Summary

- PG System - Selection based on climatic conditions at project site.
 - Low temp (min pavement surface temp)
 - High temp (average 7-day max pavement temp)
- Spec requirement remains constant; test temp changes.

Who's Using PG?



What's Happening Elsewhere?



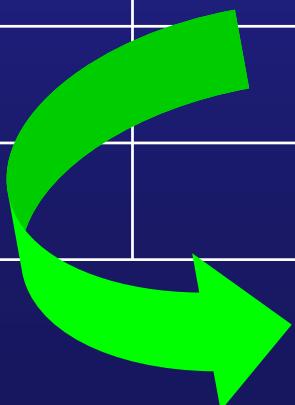
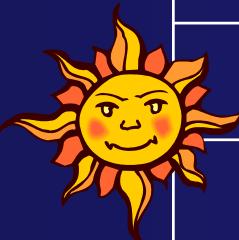
Binder Topics

- Needs based on climate
- Used
- Special cases

AZ - PG "Needs"



	-34	-28	-22	-16	-10
40					
46					
52		3	4		
58		6	12	1	
64		2	17	15	5
70				18	33
76					45

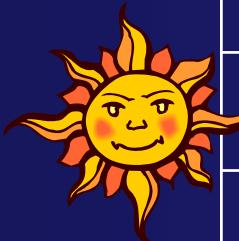


12 PG Binders!

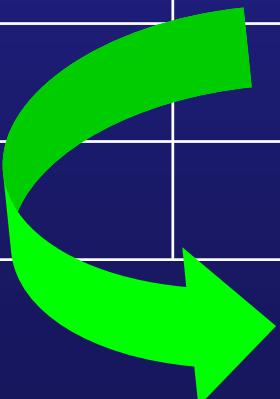
Arizona

- PG Binders Used
 - 76-16
 - 70-10
 - 64-22
 - 58-28
- No Polymer-Modified Binders!
- PG 64-16 & 58-22 ➔ asphalt rubber base stock

CO - PG "Needs"



	-46	-40	-34	-28	-22
40				5	
46		1	11	4	
52			17	16	1
58		1	7	39	3
64			3	50	11
70				1	
76					



15 PG Binders!

Colorado

1996

Unmodified

- 64-22
- 58-28
- 58-22

Modified

- 64-28
- 70-34
- 76-28
- 58-40

Currently

- 64-22
- 58-28
- 58-34

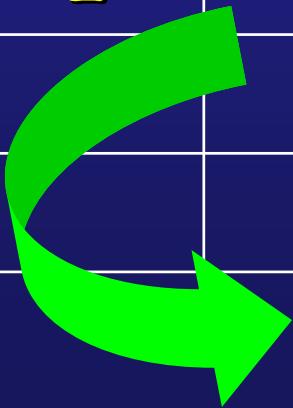
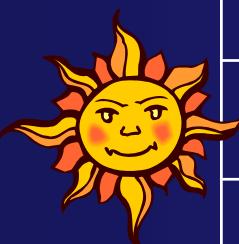
- 64-28
- 76-28
- 58-34

AASHTO M320-03;
Toughness & Tenacity, Elastic Recovery

MD - PG "Needs"



	-34	-28	-22	-16	-10
40					
46					
52		2			
58		1	5	2	
64		2	31	6	
70					
76					



7 PG Binders!

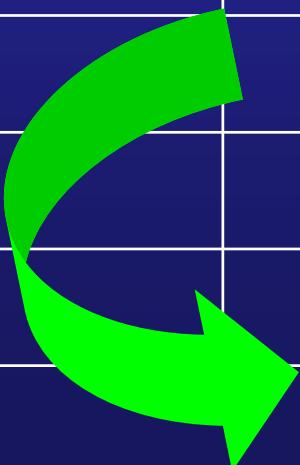
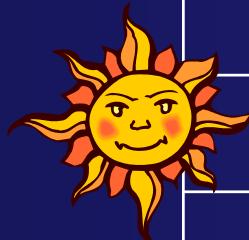
Maryland

- PG Binders Used
 - 64-22
 - 64-28
 - 70-22
 - 76-22

MN - PG "Needs"



	-46	-40	-34	-28	-22
40					
46			3		
52		24	4		
58		23	81	1	
64			1		
70					
76					



7 PG Binders!

Minnesota

- PG Grades

- 58-28

- South of I-94

- All Overlays

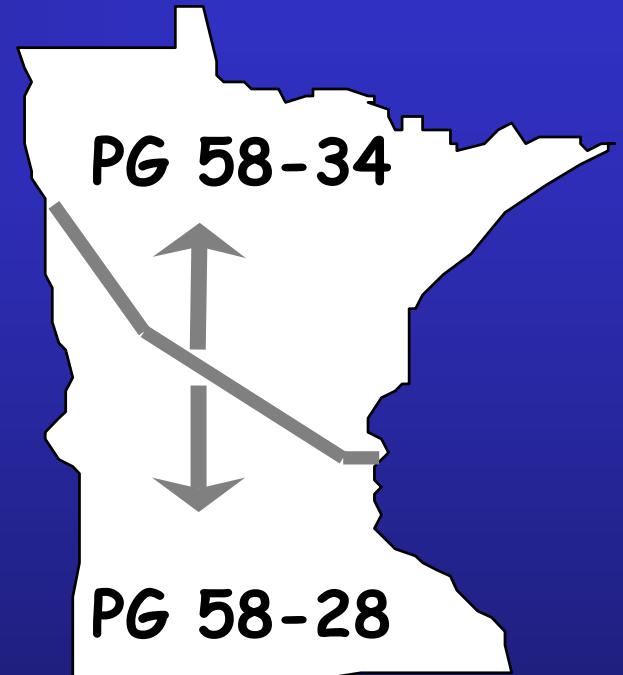
- 58-34

- North of I-94

- New Construction Only

- 64-28

- High Volume Only

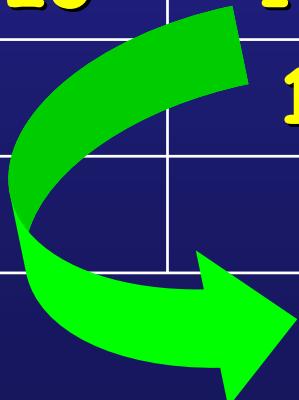




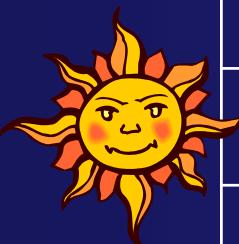
NV - PG "Needs"



	-34	-28	-22	-16	-10
40					
46					
52	1	3	2		
58	5	21	10		
64	1	23	16	1	
70			1	10	3
76				1	5



15 PG Binders!



Nevada

- PG Binders Used
 - 64-28NV
 - 76-22NV
- AASHTO 320-03; Toughness & Tenacity, Elastic Recovery
- Polymer-Modified Binders Exclusively!

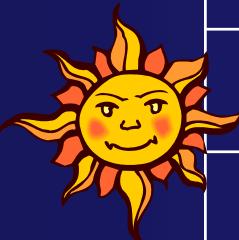
TX - PG "Needs"



	-34	-28	-22	-16	-10
40					
46					
52					
58				1	
64			24	33	16
70			4	153	134
76					3



8 PG Binders!

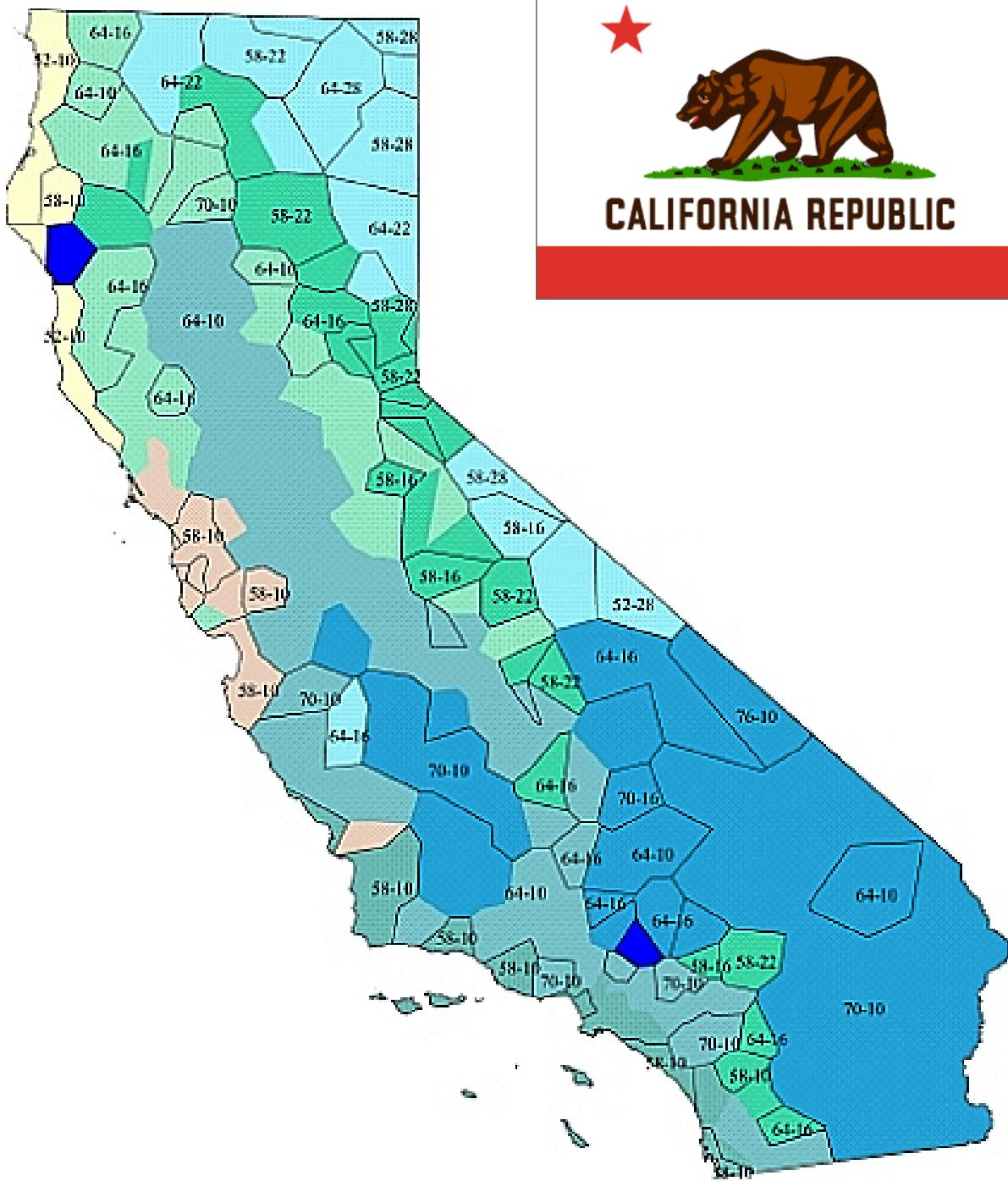


Texas

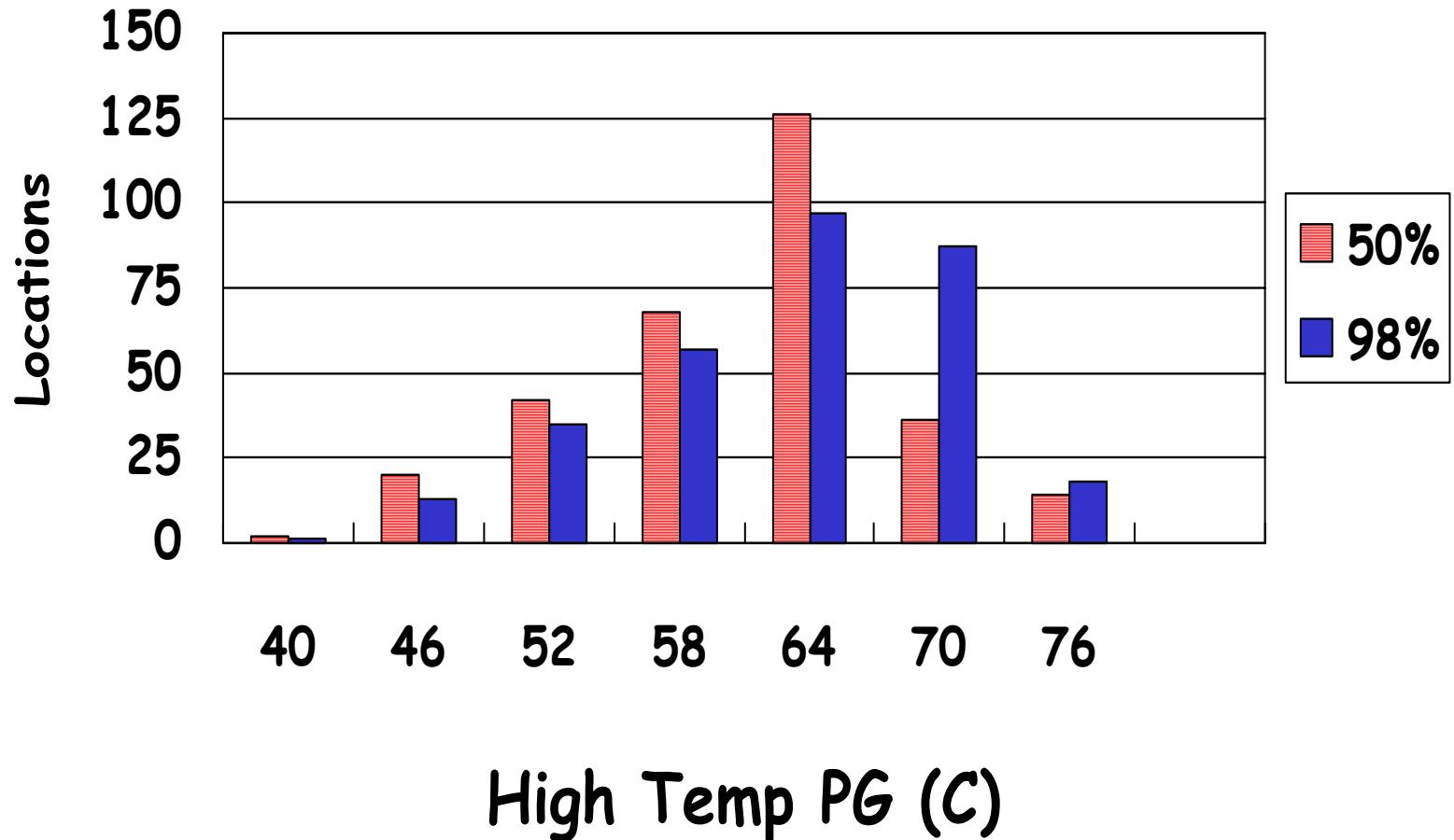
- PG Binders Used
 - 64-22
 - 70-22
 - 76-22



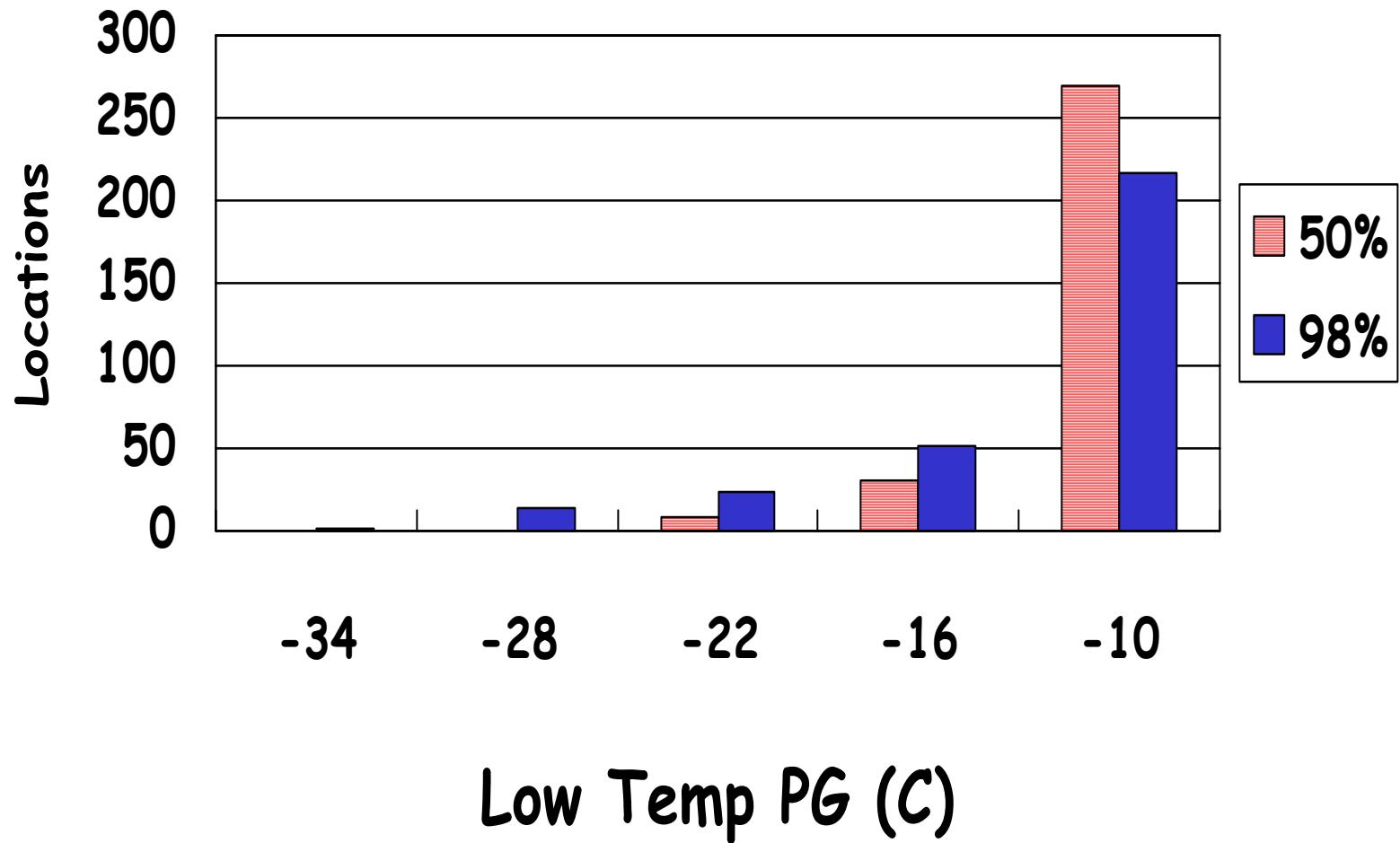
California Climate → PG “Needs”



CA - High Temp PG "Needs"



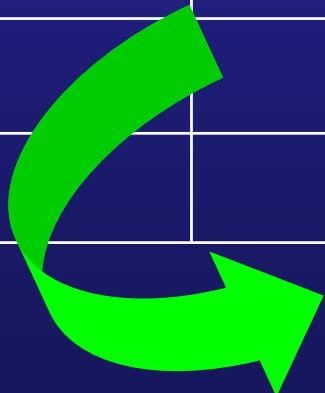
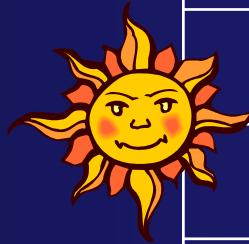
CA - Low Temp PG "Needs"



CA - PG "Needs"

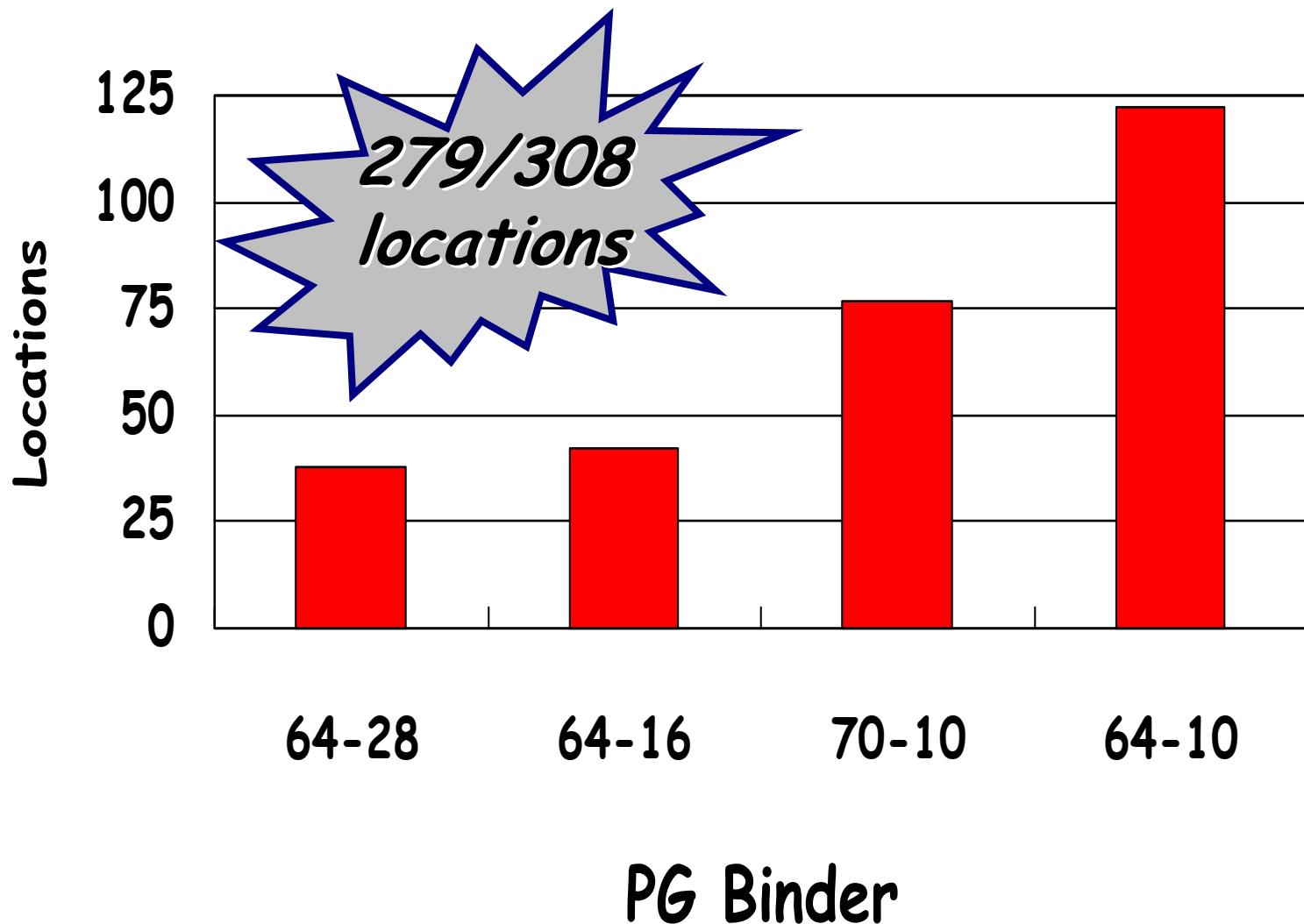


	-34	-28	-22	-16	-10
40					1
46			2	3	8
52		4	5	3	23
58	1	9	10	13	24
64		1	7	23	66
70				10	77
76					18

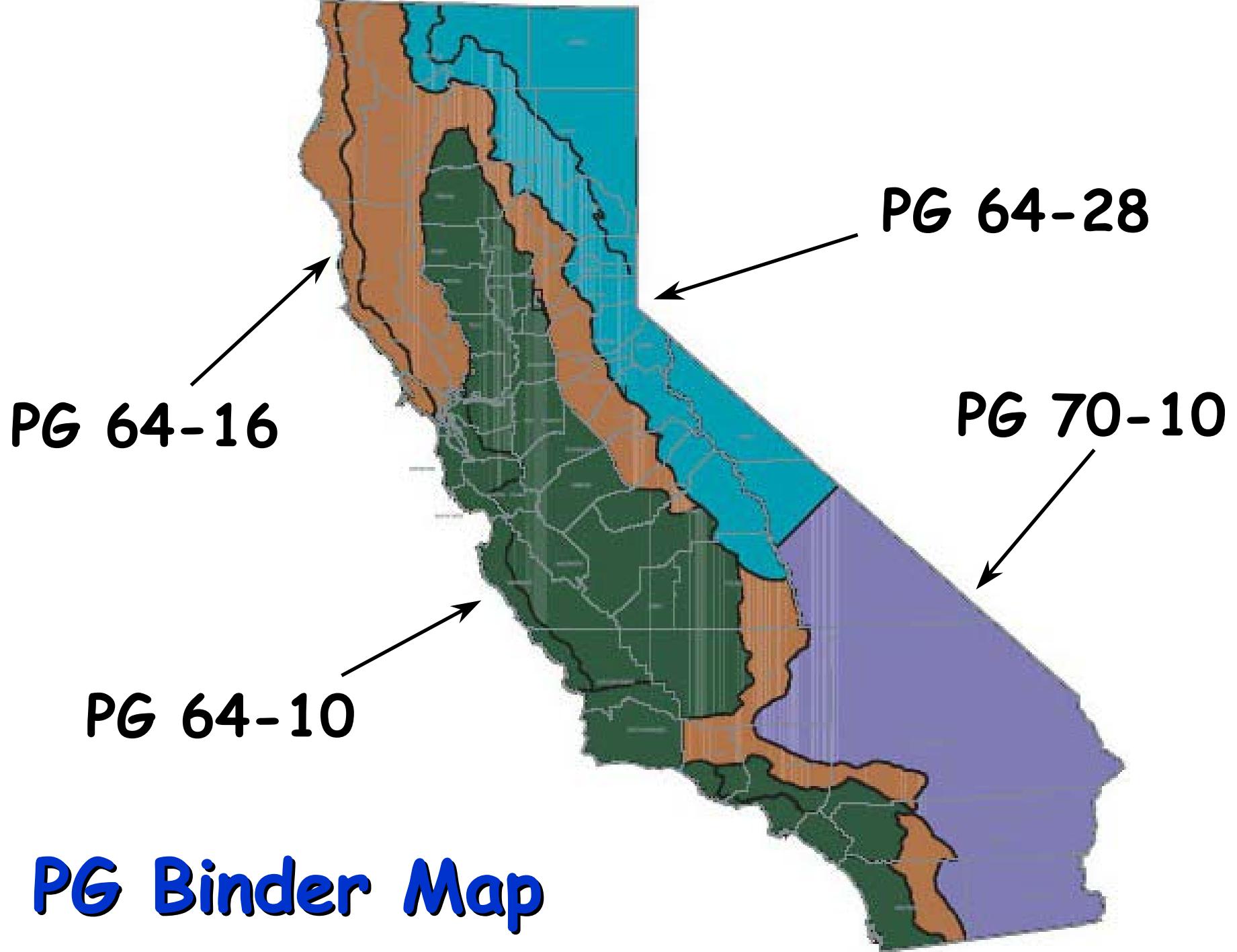


20 PG Binders!

PG Binder Distribution







Caltrans Strategy

- Special Circumstances
 - PBA 6a & 6b for cold regions
 - PBA at discretion of District... with economic justification
 - eg: Dist 9 → PBA-6b
 - eg: Dist 8 → PBA-6a*

Binders for Asphalt Rubber

PG Binder	Base for Asphalt Binder
64-10	
64-16	64-16
70-10	
64-28	58-22

Caltrans Binder Selection

Binder Climatic Region	Conventional Asphalt					Rubberized Asphalt	
	Dense Graded			Open Graded		Gap Graded	Open Graded
	Typical	Special					
	PG	PG	PBA	PG	PBA ^{\$}	PG	
S & Central Coast, Inland Valleys	64-10	70-10	6a+*	64-10			64-16
N Coast	64-16	NA	6a+	64-16	6a		
Low & S Mtn							
High Mtn & High Desert	64-28		6a, 6b	64-28			58-22
Desert	70-10		6a+, 7	70-10			64-16

* modified 6a

\$ low temp placement

Implementation

- 4 unmodified PGs - Jan 06
- Replace modified PBAs with PG - Jan 07
- Asphalt Rubber - base PG by RACTG - Jan 06
- AMRL Certification - Jan 07
- Training (Caltrans, Local Agencies & Industry)
 - Classroom: 12 Locations, Beginning Oct 05

PG Binders are not a panacea!!!

- Aggregate Characteristics
- Mix Design
- Construction Quality Control



Other Considerations

- PG for other applications?
- Mixing PG binders of same grade but from different sources?
- Critical tests for checking binders?
- Mix design approval; effect of asphalt different supplier?
- Effects of PG binders on construction process (eg, impact on compaction)?
- PG vs AR grades?



PG for Other Applications?

- Commercial
 - Parking Lots, Truck Terminals
- Ports
- Airfields
 - Commercial & General Aviation
- Residential
- Hydraulic
- Local Streets & Highways



PG for Other Applications?

- Tack Coats
 - PG 64-10 or PG 64-16
- Surface Treatments, eg, ChipSeals
 - Conventional or polymer modified emulsions
- AC Dikes
 - PG 70-10
- Crack Sealing, Expansion Joints
 - FHWA-RD-03-080



Mixing Binders - Same "PG" But Different Sources?

- Same precautions as taken for AR binders.



Critical Binder Testing?

- Spec tests
 - BBR
 - DSR (Original & RTFO-Aged)
- Use AMRL-Certified Commercial Lab!



Mix Design- Different Binder Supplier?

- Same precautions as taken for AR binders ... do another mix design!

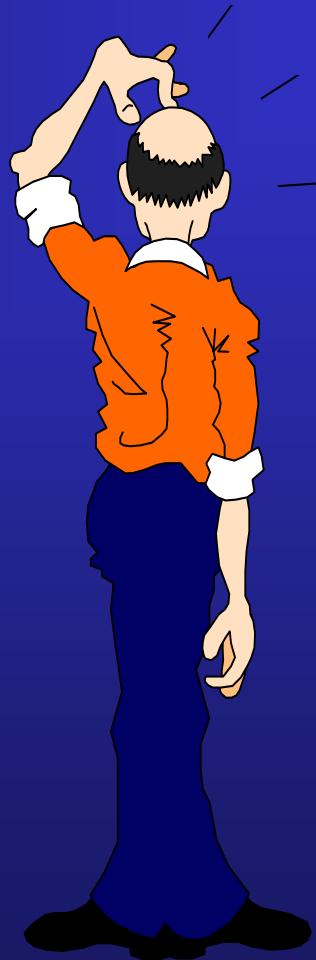


PG Binder Influence on Construction?

- Potential for stiffer binders may require higher mixing and placement temps.
- Plant production and placement temps ~ 15-20°F higher than traditional AR-graded binders.
- Another test strip?



Questions?



Comments?